WORKSHOP RECEIPTS

VOL. I

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B. G. Press—1938-39—3433B—10,000.

WORKSHOP RECEIPTS

FOR
MANUFACTURERS AND SCIENTIFIC
AMATEURS

NEW AND THOROUGHLY REVISED EDITION

VOLUME I.

ACETYLENE LIGHTING—DRYING

WITH 223 ILLUSTRATIONS

London:
E. & F. N. SPON, Ltd., 57 HAYMARKET
New York:
SPON & CHAMBERLAIN, 123 LIBERTY STREET
1909

PREFACE

THE Publishers have long been sensible of the comparative unwieldiness of the five bulky volumes to which the original 'Workshop Receipts' has grown during the past few years' and therefore the whole work has been put into the hands of competent Editors who, by the aid of experts, have thoroughly revised the vast mass of receipts and trade secrets embodied therein, and have reduced them to a greater regularity and a more accessible alphabetical arrangement. In the carrying out of this heavy task (for the survey of so wide a field is no simple undertaking), they have been careful to eliminate all information which was obsolete, to submit the remaining matter to experts for careful revision, and to amplify those sections dealing with Handicrafts. Due acknowledgment of the sources of information has been made in the text, but the Publishers desire especially to express their indebtedness to the Council of the Royal Society of Arts for permission to make extracts from their invaluable Journal. The Publishers present to the public the first volume of the revised work with full confidence that those who have used it in the past will find that it maintains the standard of sound, common-sense practicability, by which 'Workshop Receipts' has been distinguished for so many years.

CONTENTS

PAGES

ACETYLENE LIGHTING 1–5
ACIDIMETRY 5–7
AERATING AGENTS 7–8
ALBUMEN 8–13
ALCOHOL 13–24
ALCOHOLOMETRY 25–28
ALKALIMETRY 28–29
ALKALOIDS 29–40
ALLOYS 40–78
ALUMINIUM PAPER 79
AMALGAM 79–81
AMBER 81
ANEMOMETERS, AND THE DETERMINING OF AIR CURRENTS 81–86
AQUA FORTIS 86
AQUA REGIA 86
AQUARIUM, REPAIRING LEAKS IN 87
BAKING POWDERS 87–90
BALL VALVES (NOISY) 91–92
BAMBOO WORK 92–94
BAROMETERS AND WEATHER GLASSES . . . 94–105
BASKET MAKING 105–112
BELL FOUNDING AND BELL METAL 112–115
BELTING 115–116
BITTERS 117–118
BLACKBOARD WASH OR LIQUID SLATING . . . 119
BLACKINGS AND LEATHER POLISHES . . . 120–128
BLEACHING 129–145
BOILER CORROSION 145–146
BOILER INCRUSTATION AND BOILER COMPOSITIONS 146–152
BOILER AND PIPE COVERING COMPOSITIONS . . 152–153

	PAGES
BOOKBINDING AND BOOK REPAIRING . .	153–193
BRIQUETTES OR BLOCK FUEL	193–195
BURNISHING	195–198
CAMEO CUTTING	. 198
CAMERA LUCIDA	198–201
CAMERA OBSCURA	201–202
CANDLES AND CANDLE MAKING	202–211
CATGUT	211–215
CELLULOID AND IVORY SUBSTITUTES . .	215–221
CEMENTS AND LUTES	224–274
CHARCOAL	274–275
CHEMICAL CHIMNEY CLEANER	. 275
CHIMNEYS, THEIR ACTION AND CAUSES OF FAILURE	275–288
CHINA RIVETING	288–290
CHISEL STEEL AND ITS TREATMENT . . .	291–293
CLEANSING	293–337
CLOCK AND WATCH MENDING	337–381
COAL ECONOMISING POWDER	. 381
CONCRETE	381–386
CONFECTIONERY	387–404
COOKING APPARATUS	404–409
COOKING RANGE	409–414
COPYING	414–433
CRAYONS OR PASTELS	434–436
DAMPNESS IN BUILDINGS	436–441
DENDROMETER	441–444
DENTAL PORCELAIN	. 445
DEW PONDS	. 445
DIPPING AND COLOURING BRASS . . .	446–447
DISINFECTANTS	448–451
DISTILLING	451–466
DOOR HANGING	467–469
DRAIN PIPE JOINTING AND TESTING . . .	469–478
DRAWING	479–490
DRYING AND DESICCATING	490–518
INDEX	519

Workshop Receipts.

ACETYLENE LIGHTING.

THE ARRANGEMENT OF AN ACETYLENE LIGHTING INSTALLATION.

Acetylene can now be made (given a proper generator) by a lad or any unskilled person, without supervision and with no risk; and it can be had at a cost that compares equally with good coal-gas at about 3*s.* 6*d.* per 1000 ft. for a given candle-power or brilliancy of illumination. This is after allowing for wear and tear and interest on outlay. Should the present price of carbide go down, or should its gas-yielding qualities be increased, then acetylene will compare, of course, more favourably still.

The present cost of the gas, however, is no obstacle to its free adoption, for it is in very few country places that coal-gas costs less than 3*s.* 6*d.* per 1000 ft., and in many districts it exceeds this greatly. Probably most people would rather pay a little more for coal-gas supplied by a gas company, as the trouble of making the acetylene, small as it is or should be, is still a trouble, and the outlay for the apparatus has to be considered. Therefore acetylene is unlikely to displace coal-gas where the latter exists; but it is already a possible and strong rival to coal-gas, if it should be a question of which gas plant shall be laid down to light a village. For isolated residences acetylene has nothing to fear from coal-gas. Its possible rival at this moment is petrol.

As to how acetylene compares with paraffin oil in cost, there is much uncertainty. One authority puts oil as costing double as much as acetylene for a given light, whilst another says oil costs little more than half as much. There can be no doubt of the former being correct for a given light, but it is not quite the correct way to compare the two. When oil is used a comparatively dull light is obtained, and this is considered satisfactory for oil. If an acetylene plant is then substituted, the degree of light given by the lamp is considered insufficient, and a much more brilliant effect is looked for and insisted on. Then the second authority quoted comes nearer truth; and from inquiries made by the writer from the users of the many acetylene apparatus he has erected, it may be stated that the average of these shows that acetylene costs about 20 per cent. more than oil, but a superior degree of illumination is obtained. Acetylene, however, can show a saving of labour, for the apparatus the writer uses only takes about five minutes per day for recharging—equivalent to the time taken on two lamps in wick-trimming and refilling. It may also be mentioned that the lamp room of a large country house is a far greater menace to its safety that an acetylene generator in its hut outside.

To give an outline of acetylene gas production and consumption for those whose experience is limited, the manufacture of the carbide need not be considered. The carbide (carbide of calcium) consists of lime and carbon fused together, and is to be readily purchased in any quantities from the different factors now stocking it. This carbide is a dry, grey material much resembling ordinary gas coke, but is denser and heavier. While it is kept dry it remains unchanged, and is perfectly safe even if fire should attack it. The change comes when water is brought in contact, and the carbide is so susceptible to this, and so greedily absorbs moisture, that the little water-vapour there is in the atmosphere is quite sufficient to attack it and start gas production. It is therefore important that carbide be kept in air-tight drums, or vessels, and these should be kept in as dry a place as possible in case of a fissure or loose lid.

When water is brought in contact with carbide an immediate change occurs. The lime is slaked, hydrogen gas is given off, and this carries carbon with it. In other words the resulting gas is carburetted hydrogen, and the spent material left behind is slaked lime. It will therefore be seen that the manufacture (if this is not too great a word) of acetylene gas is simplicity itself—either some carbide thrown into water, or some water brought to the carbide.

For the details of acetylene generation reference should be made to a standard work, and for this description it may be assumed that a generator is chosen and it is necessary to fix it. A hut or house is prepared to receive it, outside the building which is to be lighted. The generator must not be fixed in a room or cellar beneath the house. The generator house must be very sheltered, or preferably heated by hot water or steam to prevent frost attacking the water in the plant. Whatever kind of generating apparatus is used, water is in it somewhere, and trouble must ensue if this freezes. Some consider that a brick-built generator house, with the doors lined with felt, can be protected by a good sized box of fresh horse manure (in which fermentation and heat set up). The writer has not had occasion to try this, but it sounds feasible.

Having made the necessary water connections to, and the gas connections from the generator, it has to be considered whether the gas shall be purified. In any case, whatever the gas is used for, it should pass through water first, and the majority of generating apparatus provide for this. The evolution of the gas is accompanied by heat, much the same as when ordinary quicklime is slaked, and the gas whilst warm carries vapours that can well be dispensed with. Condensation of these vapours is easily effected by passing the gas through cold water.

The condensation of condensible vapours, however, is not complete purification, and for residence work, or anything other than, say, such places as brick works or comparatively open factories, a purifier must be used. This appliance removes the gaseous impurities which pass unchanged through the condensing process, but which, if burned, cause a haze and an odour which cannot be borne in rooms. It is peculiar that in trying an apparatus minus a purifier, there may be no haze or smell for several days; then there comes a bad day, which shows how necessary the purifier is. It also shows that some of the carbide is good enough to yield a pure gas, and a purifier is chiefly necessary therefore to deal with occasional bad pieces or quantities of material.

If a purifier is used, and fully three-fourths of the works erected need one, the gas service is taken from the holder directly to it, with perhaps no more than 2 or 3 ft. of pipe between. If there are washers, or water chambers for condensing, in the generating apparatus, the gas would, on leaving the generating chambers, first go through these, then proceed to the holder. As the gas leaves the holder it next has to pass through the purifier, and then passes directly to the house. It is best not to put the purifier between the generator and holder, although at first thought it might be considered correct to do so. A purifier gives best results if the gas passes through it slowly and as regularly as possible. This result is best attained on the house side of the holder. If placed between generator and holder the gas passes through more in rushes, and the general effect is not so satisfactory.

The service piping is arranged much the same as ordinary gas piping is, except that the pipes may be much smaller. At the lowest point in the piping, usually where the gas first enters the house there should be a syphon-box, or some such provision, to receive the water that will collect in gas pipes. This is an ordinary provision with any gas-piping system, to dispose of "water in the pipes" as it is called.

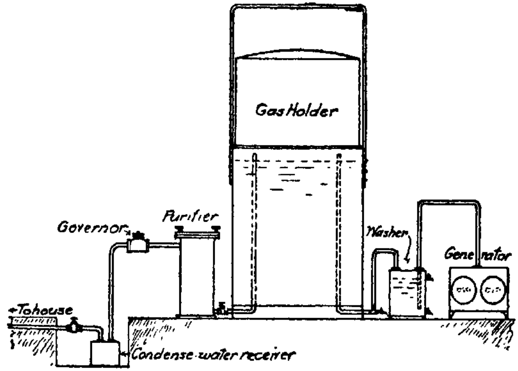

FIG. 1.

An appliance that should appear in all but the smallest installations is a "governor" or pressure regulator which automatically controls the pressure of gas in the house services.

This is of greater advantage with acetylene than with coal-gas, as any extravagance with the former means a greater waste of money than with the latter. It takes approximately fifteen times the volume of coal-gas as it does acetylene to afford a given light for a given time, therefore in the case of waste, a certain amount of acetylene, say a cubic foot, being wasted is equal to losing 15 cubic ft. of coal-gas. In other words it is, as regards monetary loss, much more desirable to prevent waste of acetylene than coal-gas. The governor will do this quite satisfactorily.

Having described the general arrangement of the various appliances included in a complete plant, a sketch, Fig. 1, is given to make the description more readily understood by those new to the work. No shape or form is given to the generator, as no particular make can be inserted here. The sketch is merely to show the order in which the parts come. They need not necessarily be in a line, but as a rule they are all in the generator house. Quite usually the generating chamber and washer are attached to the gas holder.

As regards leaks in pipes, a slight issue of gas may not be considered any more dangerous than such a leakage of coal-gas, but it represents a greater monetary loss. As just stated, if a cubic foot of acetylene leaks from a fissure in one hour, the cost is equal to about fifteen such leaks in coal-gas piping.

Respecting the sizes of gas services, the following are those customarily used, allowing for the pressure being reduced by the governor. With higher pressures, smaller pipes would suffice, but higher than normal pressures are distinctly bad in results.

Number of ¾ foot Burners.	Size of Pipe. in.	Number of ¾ foot Burners.	Size of Pipe. in.
2 . .	⅛	35 . .	⅝
5 . .	¼	50 . .	¾
10 . .	⅜	70 . .	1
20 . .	½		

Ordinary iron gas tube is used, also compo pipe, but the latter would not appear in good work. The pipe should be given a rise all the way from its starting point, or from the syphon-box previously alluded to. This is the customary provision with all gas piping systems.

The brackets, pendants and fittings can be of ordinary good quality, but there are now special fittings being made and it is desirable to use them. Acetylene is described as a searching gas, meaning that it will find (pass through) a smaller and less important leak than coal-gas; consequently a badly made fitting, or the wear and tear to ordinary fittings, is sooner brought to notice. The special fittings are made so that they are being perpetually ground in as they are used, and this keeps them sound much longer. This applies to the wearing parts, of course—the cocks, bracket joints, and cup and ball joints.

No fittings or tubes or any other parts should be of copper. Brass, although it is an alloy of copper, may be used freely.

The burners used for acetylene are specially made for this gas, and they should be kept of one candle-power or size as far as possible, because burners of different candle-powers require different pressures of gas to give the best results. Burners varying five or even ten candle-power do not show any difference to speak of, and this degree of variation is permissible; but to have 20 and 50 candle-power burners on the same piping must result in one or the other being less effective or less economical than it should be, unless the governor is adjusted for the large burners and the bracket taps are carefully adjusted for each smaller one. It is better in such a case to have double burners for the large ones, a burner that gives two 25 candle-power flames. This would reduce the variation in size of burners to the permissible limits.

A ¾ foot burner is the size generally used for residence work, or any living rooms, and this is the most desirable size as a rule; but there remains the fact that the larger the burner the more economical of gas it is, or perhaps it should be said the more candle-power you get per cubic foot of gas burned. Therefore, if an installation required a number of 1 foot burners, then it would be the most economical to use these and trust to the bracket taps being regulated for the smaller ones. Or, better still, try and arrange for all the small burners to be on a separate service, and put a separate governor to them.

For ordinary purposes a 25 candle-power flame is allowed to each 100 superficial feet of floor space, for lighting living rooms. It will be noticed that a 25 candle-power lighting flame, not burner, is mentioned, for burners vary much in their rated candle-power and the candle-power of the flame they give.

When the apparatus is thus completed it has to be tested, and this is done from the house side of the governor, as the test must be of a higher pressure than the governor would allow unless its inner mechanism were removed. The appliance or gauge used for this is as Fig. 2; it need not be purchased as it can be readily made. It is customary to test with a pressure of 10 in. of water, and good work should not only bear this but much more. After testing, the gas can be turned on and the working pressure is then fixed by attaching the testing apparatus to a bracket, and then adjusting the weights of the governor until the pressure is obtained there. A 2½-in. pressure gives the best results with ¾ foot burners, but with burners of higher power 3-in. and 4-in. pressures are needed.

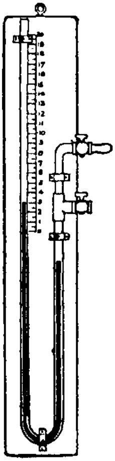

FIG. 2.

Before applying lights to the burners of the completed apparatus, it is as well to make certain that there is no air in the apparatus. Air mixed with the gas is, of course, an explosive mixture, and this should be discharged before lighting up, by allowing part of the first volume of gas to waste, to make sure of all the air being got out of the apparatus.

Having started the generating apparatus, it only remains to give the future attendant his directions as to re-charging. One important thing is to caution everyone against taking artificial lights to the gas house. An electric hand lamp would be permissible but nothing else. No such light should be needed, as re-charging can be done in daytime. A conspicuous notice of these things should be attached to the door of the generator house.

The store of carbide can be kept in the same house as the generator, or in any adjacent dry place. It must not be kept on or under the building that is lighted, or any insured building. In every case the Fire Insurance Company must be apprised, and their rules (if they issue any) adhered to..

The spent material should be white, or very nearly so, and odourless. It then consists of slaked lime with a little excess water, and it may be used for practically any purpose that such lime can be be put to. It may be used for walls, trees, etc. It will not pay, however, to attempt to dry it for any purpose. If the spent material gives off any odour of gas, it shows either that the apparatus does not use up the carbide properly or that the attendant is careless in re-charging before it is quite necessary. At the same time there are generators made with which it is difficult to wait until the carbide is all spent, as this might be after dark, when re-charging is awkward or impossible, and when the gas is needed for use. Such a generator is not the best one to use for private residence work; but if one exists, then when re-charging, the attendant has to sort the contents of the generating chamber, picking out the partially decomposed pieces and putting them back with the charge of new material. It is not a convenient arrangement, yet it must be done in such cases to admit of daylight re-charging. With such generators it is difficult to get a sludge odourless and free of gas, therefore the spent material should be dumped into a tub or pit containing water. (F. Dye.)

* * *

ACIDIMETRY.

(*See also* ALKALIMETRY.)

ACIDIMETRY is the "measuring of acids," or determining the amount of free acid in an acidulous liquid. It does not indicate the nature of the acid, nor whether more than one acid is present. Three principal methods are available: (1) The strength of an acid solution may be approximately determined by its boiling-point; (2) by its specific gravity; (3) by the amount of carbonic acid gas evolved from bicarbonate of soda by a measured quantity of the acid liquid. This last is perhaps the simplest process, and that generally in use. The apparatus required is shown in Fig. 3, and may be constructed by the operator. It consists of a wide-mouthed flask A, furnished with a tightly fitting cork, through which pass 2 glass tubes *c d*. The tube *c* terminates in a bulb B, filled with chloride of calcium; the bent tube *d* reaches nearly to the bottom of the flask. A carefully weighed quantity of pure bicarbonate of soda is introduced into the flask, and covered with distilled water. This done, a small glass test tube, containing a known volume of the acid to be examined (which must not be sufficient to decompose the whole of the alkali) is carefully lowered into the flask, in the position shown. The flask is then corked up, and accurately weighed on a delicate balance. After this, the acid in the test-tube is run out upon the alkali by causing the tube to slip into a horizontal position. By this means, a part of the alkali, equivalent to the amount of real acid in the liquid, is decomposed, the carbonic acid gas evolved escaping through the bulb-tube B; any moisture which may be carried upwards mechanically is absorbed by the chloride of calcium, whose affinity for water is well known. When the whole of the acid has been neutralised, and the disengagement of gas has ceased, air is sucked through the tube B in order to withdraw any gas remaining in the flask and tubes. When perfectly cool, the whole apparatus is reweighed. The difference between the two weighings represents the weight of carbonic acid expelled, and from this the amount of real acid in the volume of liquid operated upon is calculated by multiplying it by the combining weight of the acid and dividing the product by 44, the combining weight of carbonic acid gas. Thus, suppose the weight of the apparatus before the experiment be 32·355 grm., and after the experiment 31·785 grm., the loss in weight, ·570 grm., represents the amount of gas evolved from the bicarbonate of soda by the acid (say sulphuric acid). Then, $\frac{\cdot 570 \times 98}{44} = 1\cdot 27$ grm. of real sulphuric acid, the amount contained in the volume of liquid taken for experiment. The same method applies to the estimation of any acid which decomposes carbonates, the combining weight of such acid being substituted for that of sulphuric acid used in the above example.

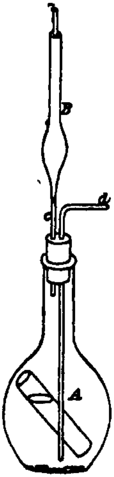

FIG. 3.

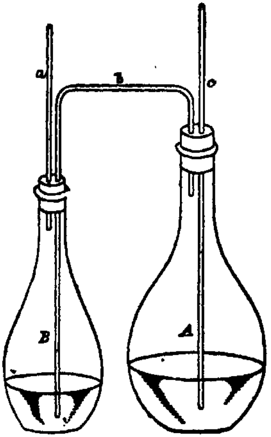

FIG. 4.

Another application of the same principle is a method devised by Fresenius and Will. The apparatus is shown in Fig. 4, and consists of 2 small flasks, A B, A being slightly the larger. These are furnished with tightly-fitting corks, through each of which pass the glass tubes *a b c*, arranged as shown. The flask B is half filled with concentrated sulphuric acid, and in the other is placed the acid to be tested, accurately measured, and, if necessary, diluted with water. A test tube is now introduced into the flask A, in the same manner as described in the previous case; this tube contains bicarbonate of soda, in quantity more than sufficient to neutralise the whole of the acid contained in the sample. After carefully weighing the apparatus, the acid and alkali are allowed to mix; carbonic acid is evolved, passes through the sulphuric acid in the other flask, being thereby thoroughly dried, and escapes through the tube *a*. All effervescence having ceased, air is drawn through the 2 flasks by sucking at the extremity of the tube *a*, to remove any traces of carbonic acid remaining behind. When quite cool, the apparatus is reweighed, the loss representing the amount of carbonic acid disengaged from the alkali. The calculation to find the total quantity of acid in the volume of liquid employed is, of course, the same as in the preceding example.

Determining acidity of vinegar.—This can be done by the neutralisation process, which is that of neutralising a certain quantity of vinegar with a normal solution of caustic soda. This solution contains 40 grm. of pure caustic soda in 1 litre, or 1 c.c. contains ·04 grm. of the soda. The strength of this can be checked by titration with a normal solution of hydrochloric acid. To determine the acidity of vinegar, 20 c.c. are measured into a beaker. Into this are put a few drops of an alcoholic solution of the indicator phenolphthalein. The soda solution is added drop by drop (a burette being used), the vinegar being agitated all the time. Immediately there is the slightest excess of the soda a deep pink colour will be noticed, at which moment the addition of soda solution is stopped and the amount used is noted. The following calculation will then determine the strength of the vinegar; 1 c.c. of the soda solution (carrying ·04 grm. of soda) is equal to ·06 grm. of acetic acid, so that 21 c.c. of the former are needed to neutralise 20 c.c. of vinegar. The amount of acid in 100 pints of vinegar is ·06 × 21 × 5 = 6·3 per cent.; as a rule the acetic acid in vinegar is 5 per cent. or a little less.

Standard solutions, acid or alkali.—These are solutions of exact known strengths. Usually they are "normal," but a deci-normal is also used; the latter being one tenth as strong as the former; of hydrochloric acid there are 36·5 grm. in one litre of the normal solution and one tenth of this amount in the deci-normal. To find the strength of an acid or an alkali, a certain quantity, say 20 c.c., is measured off, then it is titrated with either an alkali or acid, using an indicator, litmus for example, which changes colour as soon as the point of neutrality is arrived at. The standard solution is always added from a burette, drop by drop, and when neutralisation takes place, the amount of solution used is noted, and from this the amount of acid or alkali, present in the liquid being tested, is calculated.

◆

AERATING AGENTS.

Eggs.—Eggs, and especially their whites, have a peculiar glairy consistence. In virtue of this, if eggs be present in a mixture, any air incorporated with it prior to baking, is retained much more tenaciously. Consequently, when the goods are placed in the oven such air, expanding with increase of temperature, increases the volume of the articles by its more perfect retention, as a result of the peculiar viscous and binding nature of the egg-albumen. Another valuable property of eggs, so far as this effect is concerned, is that of setting or coagulation. Just as in being boiled, the egg-matters become solid during the act of baking; as the temperature of coagulation is reached they begin to set, and thus fix the dough, so to speak, in its expanded state. The lightening function of eggs is therefore summed up in the statement that they do not of themselves evolve or cause the evolution of gas, but assist in its retention when developed by the expansion of air, or obtained from any other gaseous source.

Sour Milk.—Mixed with bicarbonate of soda sour milk forms a useful aërating agent and in consequence is employed in the manufacturing of scones and similar goods. The lactic acid of the milk reacts on the soda, forming sodium lactate, and evolving carbon dioxide gas. Owing to the varying amounts of acid in the milk there is no certainty as to the proportion of soda required, but if a small amount of baking powder be added the result will be more certain.

ALBUMEN.

ALBUMEN, an organic nutritive principle, is a constituent of all animal fluids and solids. The white of eggs contains 12 per cent. of albumen, and the fluid portion of blood [serum] 7 per cent. It occurs also in the flesh, in the brain, and more or less in all serous fluids. Fibrin also may be regarded as coagulated albumen. It occurs in the vegetable kingdom, in the sap or juice of many plants, such as the potato, turnip, carrot, cabbage, in the green stem of peas, in the seeds of the cereal grasses, and in many nuts.

There are two modifications of albumen, soluble and insoluble. The former occurs in the animal body, but the insoluble modification may readily be prepared from it by the action of heat. This property of becoming insoluble, or "coagulating," as it is termed, by the action of heat, is especially characteristic of this substance, and constitutes its chief value for technical applications.

Albumen contains carbon, hydrogen, oxygen, and nitrogen, together with traces of sulphur and phosphorus. Its chemical composition is:—

	Per cent.
Carbon	53·3
Hydrogen	7·1
Oxygen	22·1
Nitrogen	15·7
Sulphur	1·8
Phosphorus	trace
	100·0

Animal albumen is always associated with certain inorganic salts and free soda. It exists in the animal body in solution, in the form of an alkaline albuminate. If the white of eggs, or the serum of blood, or any animal liquid containing albumen, be incinerated, the residue is chiefly carbonate of soda. This alkali may readily be removed, and the albumen rendered insoluble, or coagulated, by the action of heat. Exposed to a gentle heat, soluble albumen gives off a peculiar, characteristic odour. It can be dried at 104° F. (40° C.) without being rendered insoluble, and in this form is usually met with in commerce. On raising the heat to 130° F. (54° C.), white fibres of insoluble albumen begin to appear; at 160° F. (70° C.) it becomes a solid, jelly-like mass; and at 212° F. (100° C.) it dries up, turning yellow and brittle, like horn. When in this condition, 5 times its weight of water will redissolve it, bringing it once more to its original consistence. The only change which the albumen undergoes during the process of coagulation is the removal, by the hot water, of the alkali and soluble salts. Its chemical composition remains the same throughout.

Albumen of good quality is recognized by its transparency when in flakes, by its flavour not being disagreeable, and by having no odour of putrefaction. Constantly stirred in cold water, it should dissolve entirely. For practical purposes, it is best dissolved in warm water, at a maximum temperature of 113° to 122° F. (45° to 50° C.). The albumen should be added gradually, and the liquid constantly stirred. The water should on no account be added to the albumen. The liquid, after straining through a fine silk sieve, is usually mixed with a small proportion of ammonia, turpentine-oil, etc., in order to prevent frothing, and make it work smoothly. Turpentine also tends to prevent putrefaction, but an addition of about 1 per cent. of arsenious oxide is said to be the best preservative. Commercial albumen is very liable to adulteration (especially the dearer egg-albumen) with gum-arabic, dextrine, flour, sugar, etc.

Blood-albumen occurs in commerce in various forms. The lowest quality is packed in casks in the liquid state, and consists merely of blood which has been defibrinated by whipping. The purer forms of blood-albumen are prepared from the blood of slaughtered animals, which after coagulation, is filtered : 5 oxen or 20 sheep, or 34 calves are said to yield the same quantity of dry albumen—viz. 2 lb. In producing blood-albumen for commerce, the objects borne in mind are the attainment of a substance whose solution is free from colour, possesses perfect coagulation, and which is cheap. The superior price of egg-albumen has led to various attempts to prepare a blood-albumen of a similar whiteness and quality. In these attempts, animal charcoal, incipient coagulation, air rendered ozonic by means of electric induction, have severally been employed, but none proved capable of producing an albumen at all comparable in value to egg-albumen.

The manufacture of blood-albumen is largely carried on in this country of recent years, and is the subject of some interesting remarks from Dr. Ballard, especially with regard to the noxious effluvia arising from it. The trade consists in the separation of the serum from the blood-clot, and the drying of the former into transparent flakes of a reddish-yellow colour, but varying in depth of colour according to the quality of the serum from which they are made. Blood-clot is absolutely worthless for the purposes of this trade if it be not fresh. The more recently the blood has coagulated, the more valuable it is for albumen making. Hence the blood-albumen makers effect arrangements for the speedy collection of blood from butchers and town abattoirs, and it is dealt with immediately on its arrival at the works. Sometimes the first process, that of separation of the serum from the clot, is carried on in some part of a public abattoir. The serum is, in such cases, sent away in casks to the establishments, where it is dried.

The blood arrives in the shallow iron vessels in which it is caught from slaughtered animals, or in casks. The clot is immediately taken out and carefully sliced (when it arrives in shallow vessels it is sliced before removal from them), and the slices are arranged upon iron strainers, each with a pan beneath, to receive the serum which flows out as the clot continues to contract spontaneously. The season of the year governs the time during which this draining is prolonged. In summer it is continued for about 12 hours, but in winter for 18 or 24 hours. The strainers, each with its pan beneath, are arranged on racks in a building which is so constructed as to be kept as cool as possible. It is also important that the building should be in such a locality as to be free from vibration caused by the passage of heavy vehicles or railway trains. From the pans, the serum is, in the best works, transferred into a settling tank, where it remains about 2 days until all the red colouring matters, etc., which may be in suspension have been deposited. At some works, where an inferior article is made, the highly-coloured serum which comes with the clot in the casks is dried, and after the clot has been drained, it is put into a cask (from which the head has been taken out) to separate the bulk still further, and the dark serum which exudes is run off for use.

About 25 to 30 per cent. of serum is thus obtained from ox-blood, and this raw material can be manufactured into either the so-called "natural" albumen, without gloss, or the "patent" glossy albumen.

In making natural albumen, ¼ lb. of oil of turpentine is added to 100 lb. of serum, and the whole is whipped for an hour with apparatus similar to the dasher of an old-fashioned churn. The turpentine not only bleaches the serum and extracts the grease, but also helps to preserve it. It is allowed 24 to 36 hours to settle, when the clear serum is drawn off from the sediment. The drying is done in japanned iron dishes 1 ft. long, 6 in. wide, and ¾ in. deep. The temperature is at first about 122° F., and is raised to nearly 135° F. (57° C.) for 2 hours, after which it is allowed to fall to 118° or 120° F. (48° to 49° C.). The drying occupies about 36 hours.

The manufacture of "patent" albumen differs from the above in the use of acids. To 100 lb. of serum are added 7 dr. sulphuric acid, mixed with 6¼ oz. concentrated acetic acid, and 6 lb. water; ¼ lb. oil of turpentine is next mixed with it, and the compound is whipped for an hour. After settling for a day or more, the clear liquid is poured off, neutralised with ammonia, and dried as before. About 10 lb. of serum will yield 1 lb. of dried blood-albumen.

Both these preparations are called "primary" products, as distinguished from the "secondary" and "tertiary" products obtained from the residues left in the dishes after the drawing off of the pure serum and from the clot on the sieves. The albumen from the last-named source is, of course, of very inferior quality, but is largely used in sugar refining.

The well-known faint odour of blood always pervades an establishment of this kind, and is especially marked in the drying chamber; but it does not pass beyond it in any such way as to cause a nuisance, unless the manufactory be very badly conducted. The two ordinary sources of nuisance from blood-albumen works consist: (1) In the effluvia of putrid blood arising from the exhausted clots retained on the premises prior to removal. (2) In the general disagreeable faint smell proceeding from the yard premises, especially when due cleanliness is not observed. (3) In effluvia from other and further processes, such as blood-boiling or blood-manure making, carried on upon the premises. As to the remedies for nuisances, Dr. Ballard observes: (1) It is a practice in some works to throw the exhausted clot into a clot-bin, where it is left until removal. But now, in the best works, the clots are at once put into moderately sized casks, through a sufficiently large opening at one end, which, when the cask is full, is closely fastened down with a cover secured by screws. (2) Such works as these require to be conducted in a very cleanly manner. The yard should be well paved with stone, set so that no water may lodge upon it, and so that any offensive liquids that may reach it may not form pools, but flow readily away to the drain inlet. It should be kept at all times well swept up, and should be daily washed down with water. The separation room and the room in which the clots are sliced, when very near inhabited houses, should be closed in on all sides, and ventilated at the roof, as recommended for slaughter-houses, and they should be well and evenly paved. The best kind of pavement for such a room is one of cement. Flagstones are apt to crack or loosen, and the pavement to become uneven, and thus liable to retain pools of liquid matters, or to the insinuation of these liquids between and beneath the stones. Nothing can be more objectionable than a wooden floor. The floors should be frequently scrubbed and cleaned, all the vessels and implements used ought to be regularly cleansed, and the whole interior of the buildings periodically limewhited. The vapours from the drying chambers should be discharged at an elevation greater than that of adjoining houses.

A. H. Allen states that the qualities of blood-albumen as made by the leading firms are "refined," "prime," "No. 1," "No. 2," and "black." "Refined" is made from highly rectified serum, and is of a dirty-yellow colour; like "prime," it is employed as a mordant for printing delicate colours. "No. 1" is darker-coloured and of less value, though suitable for all ordinary printing purposes. "No. 2" is made from the second drainings of the serum, which, after the clear top serum has been siphoned off, is more or less tinged with red, and consequently only fit for printing dark colours; as a rule it also contains some insoluble matter, which is objectionable. "Black albumen" or dried blood is obtained from the last portions of serum, and is almost black in colour. It is not used in calico printing, but finds applications in sugar refining, and Turkey red dyeing.

C. T. Kingzett has patented a process of bleaching blood-albumen, and at the same time preserving it from putrefaction, by aerial oxidation of certain hydro-carbons in the presence of the albuminous solution to be bleached at a temperature below the coagulable point. Thus, if turpentine be employed, peroxide of hydrogen is formed on the one hand (and this bleaches the albumen), while other substances are simultaneously produced in sufficient quantity to preserve the mass from putrefactive decomposition. This process has been worked on serum and dark-coloured scales, producing solutions containing 2 to 4 lb. of albumen per gallon. The existence of the salts present in serum does not interfere with its photographic applications.

Egg-albumen. — Albumen may be prepared in a pure state from white of eggs, by the following method: The white of eggs is beaten up well with water and filtered. To the filtrate is added a small quantity of sub-acetate of lead, in order to remove the mineral substances. The whole of the albumen is now precipitated as albuminate of lead. This is stirred up with water, and carbonic acid gas is passed through, by which the albuminate of lead is decomposed; carbonate of lead is precipitated, and the albumen remains in solution. The carbonate of lead is now filtered off through paper which has been washed with dilute acid. Traces of lead still remain, and to remove these the filtrate is treated with a few drops of aqueous sulphuretted hydrogen, and gently heated. The first flocks of albumen which appear, retain the whole of the lead as sulphide. This is filtered off, and the filtrate evaporated gently in a basin, the residue consisting of pure soluble albumen.

The yolks of the eggs are mostly used in the preparation of glove-leather, sometimes under the name of "egg-oil."

In preparing egg-albumen there is considerable difficulty in completely separating the white from the yolk. Campe recommends that the whites should be refined by whipping up with oil of turpentine and a trace of acetic acid, and allowing the whole to stand for 25 to 36 hours, when the oil floats on the surface, and carries impurities with it. From a pecuniary point of view, this process does not appear to be advantageous, at least not in Moravia, Silesia, and Saxony.

An important condition in the production of albumen from eggs is the possibility of easily disposing of the yolk. Since this cannot always be done in the neighbourhood of albumen factories, and as transporting the material to a distance is apt to produce decomposition, it is necessary to add to it some antiseptic substance. Campe finds a solution of soda arsenate in glycerine, to which some salt is added, best suited for the purpose.

Carbolic acid, soda hyposulphite, etc., have been more or less successfully tried, but found objectionable on the part of tanners and glovers, who are the chief consumers of yolk of egg. The former imparts to the leather its penetrating smell, the latter produces stains.

Fish-albumen is not unknown in the market, and may be recognised by its fishy odour. Hilman's process for preparing it is as follows: The crushed spawn is macerated in sufficient water to dissolve out the albumen. The albuminous water is separated by filter press, and evaporated in a vacuum-pan nearly to dryness. The thickened mass is then dried on drying floors, salicylic acid, in the proportion of 1 to 20, being added as a preservative. There are difficulties in the way of freeing fish-albumen from accompanying substances, which reduce its value.

Vegetable-albumen is most easily prepared from potatoes, by cutting them into slices, covering them with very dilute sulphuric acid (2 per cent.), leaving them 24 hours, then adding fresh potatoes and repeating the operation once more, afterwards neutralising with potash and boiling. A considerable quantity of albumen is then deposited in thick white flocks. It can also be made from wheat-flour and from oleaginous seeds. Kingzett's and Portheim's processes, briefly alluded to under "Blood-albumen," are equally applicable to gluten, the protein of worts, etc. The latter inventor takes 100 lb. of the albuminous matter, ground up and washed with water, and dissolves it in 200 to 250 lb. of water, in which has been previously dissolved 4 lb. of caustic soda or potash at 194° to 212° F. (90° to 100° C.). To the solution thus prepared he adds 4 per cent. of a solution containing 40 per cent. of glycero-sulphate or glycero-phosphate of calcium, or 4 per cent. of a mixture of calcic chloride and an alkaline salt of citric, tartaric, or meta-phosphoric acid. The mixtures are "scaled" in the usual way.

Albumen in powder.—If blood serum, or white of egg, is exposed in thin layers, and a current of dry air passed over it, it will become a solid transparent substance like horn. It will keep well in this state, or it may be reduced to powder and stored in bottles.

For use in photography, 3 teaspoonfuls of cold water added to every ½ teaspoonful of powder represent the normal consistence of egg albumen.

Preserving Albumen.—It is often required to keep fresh white of egg for a considerable time ready for use. Oil of cloves or salicylic acid will do this for a moderate time, but for proper preservation a poisonous substance must be resorted to, and of these carbolic acid is best.

According to Berg's process for preserving egg-albumen for photographers, the whites, separated from the yolks, are evaporated to dryness in zinc or porcelain basins, at a temperature of 113° F. (45° C.), the operation being conducted *in vacuo*, to hasten the evaporation. The solid albumen thus obtained is reduced to powder, which, if kept perfectly dry, may be preserved for a long time without alteration, and is applicable to all ordinary purposes.

Restoring Insoluble Albumen.—According to Wagner and Witz, albumen which has been coagulated (rendered insoluble) may be restored to the soluble (coagulable) state by means of treatment with pepsin. By Wagner's plan 12 to 13 oz. of insoluble albumen are placed in contact with 1 oz. of calf's stomach, cut into little pieces, and distributed through 1¾ pints of water, previously treated with ⅛ oz. concentrated hydrochloric acid, and having a temperature of 100° F. (37½°C.). After 24 to 36 hours' standing, the whole is passed through a fine sieve, and the filtrate neutralised with ammonia.

Witz uses sheep's stomach, and over 4 oz. of dry insoluble albumen to 1¾ pints of acidified water, digesting for 40 hours at a temperature of 95° to 104° F. (35° to 40° C.), whereby about half the albumen goes into solution. This portion is removed by filtration, and the insoluble residue is again treated in the same manner to yield a second portion of soluble albumen. Pigs' stomachs are even more active than sheep's. The solution of albumen obtained by Witz is odourless and colourless, and, after the neutralisation with ammonia, coagulable either by heat or alcohol. More, it does not gelatinise, even after long standing. The addition of the hydrochloric acid is essential to success with the pepsin processes. Indeed, dilute hydrochloric acid (1 part of 1·169 sp. gr. in 100 water) alone, at a temperature of 100° F. (38° C.), after some days effects the solution of insoluble albumen, affording a solution which will coagulate on boiling.

ALCOHOL.

(*See also* DISTILLING SPIRIT, EVAPORATING, PERFUMES, ETC.)

THE following matter will be found to deal with the general subject of alcohol, so far as the space will admit, while further information will be found under the sub-heading of Spirit in the subject entitled Distilling. The purposes to which alcohol are now put are very varied and great in number, while it may be estimated that the "denaturing" of alcohol, making it into what is commonly known as Methylated Spirit, has given a stimulus to distilling that can be only described as enormous. As will be seen, Methylated Spirit, is simply alcohol which has had a substance added that gives it a disagreeable odour and flavour, making it unfit to drink, though remaining alcohol in all other respects. The important effect of this is that the spirit then is no longer subject to the heavy excise duty that alcohol has otherwise to bear. With this duty added the cost of alcohol prohibits its use for the great number of purposes to which the denatured or methylated spirit is put. As a motive power or an illuminant for instance the taxed alcohol has a prohibitive price, but minus the tax the spirit is of growing commercial or rather industrial importance. Methylated spirit, it may be added, derives its name from the fact that the alcohol of sugar (ethyl alcohol) is usually converted by the addition of a small percentage of the alcohol of wood (*methyl* alcohol). Although alcohols of other names and having different chemical formulæ can be produced from many vegetable, and some other substances, the two named above are those which chiefly concern the distiller. Alcohol does not occur in nature, but is the product of the decomposition of glucose [uncrystallisable sugar], which, under the influence of certain nitrogenous substances called "ferments," is split up into alcohol and carbonic anhydride, the latter being evolved in the form of a gas, while the former remains behind mixed with water, from which it is separated by distillation. All substances containing sugar, or substances which can be converted into sugar (e.g. starch), are "alcoholisable," or capable of yielding alcohol. The manufacture of alcohol on a commercial scale is too large a subject for discussion here, and may best be studied in such works as Spons' Encyclopædia (pp. 192–229), but the chief varieties deserve a brief notice. In all cases (except caustic alcohol) the same operations have to be carried out, viz. (1) fermentation, to convert the glucose into alcohol; (2) distillation, to separate the water and alcohol; (3) and these are followed by rectification. Fermentation and distillation are described in another section, but rectification will be discussed at the end of the present article.

Caustic-alcohol.—This term is commonly applied to sodium ethylate, a product formed by the decomposition of absolute alcohol with pure metallic sodium, the chemical formula being $C_2H_5 . NaO$, or alcohol which has had one atom of its hydrogen replaced by one of sodium.

Dr. Richardson gives the following directions for preparing a solution of the proper strength for use: Place ½ fl. oz. of absolute alcohol in a 2-oz. test tube surrounded by a water-bath at 50° F. (10° C.); add sodium in small pieces to the alcohol so long as gas is given off; then raise the temperature of the bath to 100° F. (38° C.), and add more sodium so long as it continues to dissolve; lastly, cool to 50° F. (10° C.) and add ½ fl. oz. more absolute alcohol. There are several obvious objections to this method, in the time occupied, the long exposure to the air of such hygroscopic bodies, and the varying strength of the product. To remedy these, Dr. L. H. Smith proposes that the solution be made from a weighed amount of sodium, with as little exposure as possible. He finds the average weight of sodium used for making 23 c.c. to be 0·635 grm., forming 1·877 grm. of sodium ethylate; this dissolved in 20 c.c. of alcohol would give a solution containing 9·385 per cent. To make a 10 per cent. (nearly) solution would need 0·68 grm. sodium for 20 c.c. absolute alcohol, and 2·01 grm. of the ethylate in 20 c.c. Dr. Smith prepares a solution of 10·05 per cent. strength as follows: 20 c.c. of absolute alcohol are placed in a test-tube, closed with a perforated cork, into which a small tube drawn to a fine point has been inserted; the test-tube is placed in a bath of ice-water; 0·68 grm. of sodium is weighed out, cut into 3 pieces, and immediately replaced in the hydrocarbon oil in which it is kept; one piece of the sodium is quickly dried of the oil, dropped into the alcohol, and the cork replaced in the test-tube. It rapidly dissolves, when the second piece is added, and finally the third, observing as the solution becomes stronger and the reaction slower, the test-tube is removed from the bath at intervals, to allow the temperature to rise, and hasten the solution. The finished solution is immediately transferred to small bottles and kept from the light. (Pharm. Journ.)

Fruit-alcohol.—The most important juicy fruit (cereals or grain will be separately considered) affording alcohol is undoubtedly the grape. For this purpose the just ripe unbruised grapes in bunches, are crushed in perforated boxes, and the exuding juice is collected in vats. The juice and the refuse ("marc") are fermented either separately or together. The resulting alcoholic liquid is distilled to afford genuine brandy or wine alcohol. Among other fruits that have been similarly utilised are apricots, cherries, peaches, currants, gooseberries, raspberries, strawberries, and figs. Acorns, freed from the shells, finely ground, mashed with malt, and allowed to ferment, yield an alcohol said to be equal to that from grain. Horse chestnuts might be turned to a similar useful account.

Grain-alcohol.—The cereals contain an amylaceous (starchy) substance, which under the influence of diastase is converted into fermentable sugar. The following table shows the possible yields from different grains:—

			Pints pure alcohol.
100 lb.	rice	give . .	24½
,,	wheat	,, . .	22¼
,,	rye	,, . .	19½
,,	barley	,, . .	17½
,,	buckwheat	,, . .	17½
,,	maize	,, . .	17¼
,,	oats	,, . .	15¼

Rice, maize, wheat, sorghum, and rye are most largely used; barley and buckwheat are added in some proportions; oats are too dear to be employed for any purpose but lending an aroma to the product of other grains.

The processes necessary to prepare grain for fermentation are:—

(1) Steeping in water for 30 to 40 hours, or until the grains yield readily when crushed between the fingers.

(2) Germination, or spreading the drained grain in beds on the prepared floors of a "malthouse," kept at 53½° F.

(12° C.); here it heats, and soon begins to germinate ("grow out"), this operation being finished when the rootlets have attained ⅔ the length of the grains, which may require 8 to 15 days. Care is needed in regulating the temperature, and the mass wants turning every 6 to 8 hours before germination, and every 3 to 5 hours afterwards, the temperature of the grain being kept at 59° to 61° F. (15° to 16° C.).

(3) Drying the germinated grain ("malt") in layers of about 12 in. in a "kiln" at a temperature commencing at 95° F. (35° C.), rising to 131° to 140° F. (55° to 60° C.),, and finishing at 176° to 194° F. (80° to 90° C.).

(4) Grinding more or less finely.

(5) Mashing the malt and unmalted grain with water at 95° to 100° F. (35° to 38° C.), to liberate the saccharine fermentable matters from the starch of the unmalted grain by the action of the diastase generated in the germination of the malt.

(6) Infusion of the mass by adding boiling water till the temperature reaches 140° to 158° F. (60° to 70° C.), then allowing to stand for 4 hours with the heat never below 122° F. (50° C.), to convert the liberated starch into glucose.

(7) Fermentation of the "wash," previously cooled down to 68° to 79° F. (20° to 26° C.), in covered vats, by adding about 10½ pints of liquid or 7lb. of dry brewer's yeast for every 250 lb. of grain used, and leaving for 4 or 5 days.

Grain alcohols are chiefly represented by gin and whiskey.

Molasses-alcohol. — Rich molasses (the impure uncrystallisable sugary product separated from raw sugars by the process of refining) contains as much as 50 per cent. of sugar. The drainings and skimmings obtained on cane estates in the preparation of sugar are included under the same term. When diluted with water, fermentation sets in rapidly. Molasses from beet-sugars are usually alkaline, and first need acidification, about 4½ lb. of concentrated sulphuric acid being added to each 22 gal. of molasses, previously diluted with 8 to 10 volumes of water. Fermentation is hastened by the aid of a little brewer's yeast, or other natural ferment; it begins in 8 to 10 hours and lasts over 60.

Cane-molasses alcohol is familiar as rum, while the beet-molasses article is generally rectified down to almost pure spirit.

Beet-sugar molasses as it comes from the sugar house may contain from 30 to 45 per cent. of sugar, and water should be added and stirred in (by hand, though usually by a machine) to a concentration of 16 to 18 per cent. of sugar. The density of the liquid is 1·060 or 6° to 8° B. To each 1000 gal. of wash add 1 gal. of strong sulphuric acid and 10 lb. sulphate of ammonia to neutralise alkaline carbonates (which otherwise retard fermentation) and to obtain vigorous fermentation.

The yeast used for fermentation is prepared from malt or grain as concentrated as possible. The "pitching" temperature of the wash varies with its strength, but for general purposes 81° to 83° F. is best. Fermentation commences at 77° F., and for strong washes as high as 90° F. is sometimes kept. About 82° F. is usually most conducive to the growth of yeast. With large vats the temperature sometimes rises quickly, and on this account it is customary for a pipe coil to be provided in the bottom, through which cold water can be run.

Cane Sugar molasses, together with the "skimmings," the washings of the pans, precipitates, etc. are all used for making alcohol, practically the whole of which goes to produce rum. The first process is that of clarifying the mixture previous to its fermentation. This is performed in a leaden receiver holding about 300 to 400 gal. When the clarification is complete, the clear liquor is run into the fermenting vat, and there mixed with 100 or 200 gal. of water (hot, if possible), and well stirred. The mixture is then left to ferment. The great object that the distiller has in view in conducting the fermentation is to obtain the largest possible amount of spirit that the sugar employed will yield, and to take care that the loss by evaporation or acetification is reduced to a minimum. In order to insure this, the following course should be adopted. The room in which the process is carried on must be kept as cool as it is possible in a tropical climate; say, 75° to 80° F. If the fermenting vat has a capacity of 1000 gal. the proportions of the different liquors run in would be 200 gal. of well-clarified skimmings, 50 gal. of molasses, and 100 gal. of clear dunder*; they should be well mixed together. Fermentation speedily sets in, and 50 more gal. of molasses are then to be added, together with 200 gal. of water. When fermentation is thoroughly established a further 400 gal. of dunder may be run in, and the whole well stirred up. Any scum thrown up during the process is immediately skimmed off. The temperature of the mass rises gradually until about 4° or 5° above that of the room itself. Should it rise too high, the next vat must be set up with more dunder and less water; if it keeps very low, and the action is sluggish, less must be used next time. No fermenting principle besides the gluten contained in the wash is required. The process usually occupies 8 or 10 days, but it may last much longer. Sugar planters are accustomed to expect 1 gal. of proof rum for every gal. of molasses employed. On the supposition that ordinary molasses contains 65 parts of sugar, 32 parts of water, and 3 parts of organic matter and salts, and that, by careful fermentation and distillation, 38 parts of absolute alcohol may be obtained, we may then reckon upon 33 lb. of spirit, or about 4 gal., which is a yield of about $5\frac{3}{8}$ gal. of rum, 38 per cent. over-proof, from 100 lb. of such molasses.

The following process is described in Deerr's work on "Sugar and Sugar Cane":—

"In Mauritius a more complicated process is used; a barrel of about 50 gal. capacity is partly filled with molasses and water of density 1·10 and allowed to spontaneously ferment; sometimes a handful of oats or rice is placed in this preliminary fermentation. When attenuation is nearly complete more molasses is added until the contents of the cask are again of density 1·10 and again allowed to ferment. This process is repeated a third time; the contents of the barrel are then distributed between three or four tanks holding each about 500 gal. of wash of density 1·10, and 12 hours after fermentation has started here, one of these is used to 'pitch' a tank of about 8000 gal. capacity; a few gal. are left in the pitching tanks, which are again filled up with wash of density 1·10 and the process repeated until the attenuations fall off, when a fresh start is made. This process is very similar to what obtains in modern distilleries, save that the initial fermentation is adventitious."

Moss-alcohol.—Large quantities of alcohol are distilled in Sweden and Russia from reindeer moss (*Cladonia* [*Cenomyce*] *rangiferina*) and Iceland moss (*Cetraria islandica*). The yield is said to be as great as from good grain, while the supply of material is abundant and cheap.

Root-alcohol. — A number of roots and tubers, including beet, potatoes, carrots, turnips, asphodel, madder, and chicory, have been availed of for the manufacture of alcohol, the most important being beets and potatoes.

Beets contain about 10 per cent. of sugar, which can be converted into alcohol in several ways, chiefly: (1) rasping and pressing the roots and fermenting the expressed juice; (2) macerating in hot water; (3) direct distillation.

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* Dunder is the liquor, or "wash," as it is termed, deprived by distillation of its alcohol, and much concentrated by the boiling it has been subjected to; whereby the substances it contains, as gluten, gum, oils, etc., have become, from repeated boilings, so concentrated as to render the liquid mass a highly aromatic compound. In this state it contains at least two of the elements necessary for fermentation, so that, on the addition of the third, viz., sugar, that process speedily commences.

(1) The roots are washed, rasped (grated), and pressed, yielding 80 to 85 per cent. of juice; this is heated to about 82½° F. (28° C.), and run into fermenting-vats; here it is acidulated with not more than 6½ lb. of sulphuric acid to every 1750 pints of juice, to neutralise the alkaline salts present, and hinder viscous fermentation. Alcoholic fermentation is assisted by the addition of about 1 oz. of yeast previously mixed with a little water to every 100 pints of juice, the external temperature being carefully maintained at 68° F. (20° C.). The alcohol produced by this process is the best but dearest, requiring most plant and labour.

(2) In the maceration process, the washed roots are cut into slices, having a width of less than ⅔ in., a thickness of $\frac{1}{25}$ in., and a variable length; the slices are covered with boiling water in a wooden or iron macerator for 1 hour, the water containing 1 lb. sulphuric acid for every 50½ lb. of beet.

The partially saturated water is next drawn off into a second vat, where more slices are added, and maceration takes place for 1 hour; and finally into a third likewise, after which it goes to the fermenting vat. In mild weather the juice will be at about the right heat for fermentation, say 71½° to 75¼° F. (22° to 24° C.), but in very cold weather reheating may be necessary. The fermentation is similar to that of pressed juice, and is usually complete in 24 to 30 hours. The alcohol thus obtained is inferior but much cheaper.

(3) Laplay's method of direct distillation of the roots is conducted in vats of 100 bushels' capacity, and a charge consists of 2500 lb. of the sliced roots, inclosed in porous bags, and immersed in 440 gal. of acidulated water, with the temperature maintained at about 77° to 80½° F. (25° to 27° C.). The addition of a little yeast starts the fermentation, which lasts about 24 hours. The slices of beets charged with alcohol are now placed in a distilling apparatus of a very simple nature. It consists of a cylindrical column of wood or iron, fitted with a tight cover, which is connected with a coil or worm, kept cool in a vessel of cold water. Inside this column are arranged a row of perforated diaphragms or partitions. The space between the lowest one and the bottom of the cylinder is kept empty to receive the condensed water formed by the steam, which is blown into the bottom of the cylinder in order to heat the contents. Vapors of alcohol are thus disengaged from the undermost slices, and these vapors as they rise through the cylinder vaporise the remaining alcohol and finally pass out of the top at a considerable strength and are condensed in a worm. When all the contents of the still have been completely exhausted of spirit, the remainder consists of a cooked pulp, which contains all the nutritive constituents of the beet except the sugar.

Potato-Spirit is made chiefly in Germany, and its manufacture has now assumed considerable importance. Potatoes contain 16 to 20 per cent. of starch, which is capable of being converted into glucose by the action of sulphuric acid or of malt. Three principal methods of effecting the saccharification are in use: (1) the potatoes are cooked, and then crushed into pulp; (2) rasped to bring about the same result; (3) the starch may be extracted and converted into sugar afterwards.

In the first method are several operations, viz. cooking the potatoes; crushing them; converting the starch into sugar by means of malt; and finally, fermentation and distillation. The operation of "cooking" is carried on with a boiler set in brickwork surmounted by a tun made of oak staves. The bottom of the tun, which must be of solid wood, is perforated with a number of small square holes to give admittance to the steam from below. The potatoes placed in this tun are rapidly cooked by the ascending steam. They are then withdrawn and crushed into a thick pulp between two rollers, commonly made of oak, and placed below the level of the tun. As the potatoes swell considerably during the steaming, the tun should never be completely filled. The pulp is placed in a vat, holding 660 to 880 gal., in which the saccharification takes place. About 2500 lb. of the crushed potatoes and 175 lb. of broken malt are introduced, and immediately afterwards water is run in at a temperature of about 86° to 104° F. (36° to 40° C.), the contents being well stirred with a fork meanwhile. The vat is then carefully closed for ½ hour, after which boiling water is added until the temperature reaches 140° F. (60° C.), when the whole is left for 3 or 4 hours. The process of fermentation is conducted in the same vat. Alternate doses of cold and boiling water are run upon the mixture, until the quantity is made up to from 700 to 770 gal., according to the size of the vat, and so as finally to bring the temperature to 75¼° to 78⅘° F. (24° to 26° C.). Liquid brewer's yeast (4½ to 5¼ pints) is added, and fermentation speedily sets in. This process complete, the fermented pulp is distilled in the apparatus devised by Cellier-Blumenthal, for distilling materials of a pasty nature (see distilling); the product has a very unpleasant odour and flavour.

(2) By rasping the potatoes, the extensive operations of cooking and separating the starch are avoided. In this operation, the washed potatoes are thrown into a rasping machine similar to those employed in sugar manufactories. If 2500 lb. of potatoes be worked at once, the vat has a capacity of 484 to 550 gal., and a perforated false bottom carrying a layer of straw. The charged potatoes are allowed to stand for ½ hour in order to get rid of a portion of their water. After this, 219 to 262 gal. of boiling water are run in, then 175 lb. of malt are added; the whole is stirred up and left to macerate for 3 or 4 hours. This done, the liquid is drawn off from beneath into the fermenting-vat; the pulp is drained for ¼ hour, and the drainings are added to the liquor previously run off. Boiling water (109 gal.) is run in upon the pulp, which is again stirred up energetically. After remaining some little time, the water is again drawn off, the pulp drained and washed anew with 109 gal. of cold water, with agitation. This is again drawn off, and the whole of the water with the drainings is mixed up in the fermenting vat. Yeast (5 lb.) is added, and the contents of the vat are left to ferment. Only the liquor is fermented by this process, but the spirit yielded is nearly as unpleasant to taste and smell as that obtained by process No. 1.

(3) The only means of obtaining alcohol of good quality from the potato is to extract the starch and convert it into sugar separately. The saccharification of the starch is effected either by sulphuric acid or diastase, the latter being decidedly preferable. In a vat of 660 gal. capacity are mixed together 220 gal. of cold water, and 1250 lb. of dry or 1875 lb. of moist starch. The mixture is well agitated, and 247 gal. of boiling water are run in, together with 180 to 200 lb. of malt; the whole is stirred up energetically for 10 minutes, and then left to saccharify for 3 or 4 hours. The saccharine solution obtained must be brought to 6° or 7° B. at a temperature of 71½° to 75¼° F. (22° to 24° C.), and 17½ oz. of dry yeast are added for every 290 gal. of must. Fermentation is soon established, and occupies usually about 36 hours. After remaining at rest for 24 hours, the must is distilled; 250 lb. of starch ought to yield 8 to 9 gal. of pure alcohol, or 9 to 10 gal. of alcohol at 90°.

(4) The following methods provide for the isolation of the fecula or starch, without steam, and the production of a wash of a more watery consistence, therefore easier to handle in ordinary stills, and with less liability to burn.

Two operations are necessary by this method: First, rasping, or reducing the potatoes to a finely crushed and pulpy condition by means of a machine described in the chapter on beet mashing; and second, the separation of the fecula.

To this latter end the potato pulp is placed on a sieve, having side walls and network of horse-hair, which is placed over a suitable tub. Water is run gradually through the pulp and sieve, while the pulp is rubbed up by hand. When the water comes through clear, then all the fecula of the pulp has been washed out, and the refuse left in the sieve can be thrown aside or used as a food for cattle.

For a mashing tub of say about 32 bushels capacity, the fecula from about 800 lb. of potatoes is used. This is deposited in the mash tub with sufficient cold water to form a fairly clear paste. About twice as much water as fecula will bring the paste to proper consistence. This mixture should be constantly stirred, as otherwise the fecula will sink to the bottom. About 40 gal. of boiling water are then added gradually. The mixture has at first a milky appearance, but at the last becomes entirely clear.

This liquid is mashed with about 45 lb. of malted barley or Indian corn, ground into coarse flour. In 10 minutes the mixture will be completely fluidified. It is then left to subside for 3 or 4 hours, when it will have acquired a sweetish taste and be what is termed as "sweet mash." The fluid is then further diluted by the addition of sufficient water to give about 290 gal. of wash. Two or 3 pints of good yeast will bring this mixture to a ferment.

A less laborious method of accomplishing the same result is that at one time used in English distilleries. In this a double bottom tub is used, the upper bottom of which is perforated, and raised above the solid lower bottom. A draw-off cock opens out from the space between the two bottoms.

Assuming that the tub is of 220 gal. capacity, then from 12 to 20 lb. of chaff are spread over the perforated bottom and pulp from 800 lb. of raw potatoes placed on that. This is thoroughly drained for half an hour, through the draw-off cock. The pulp is then stirred while from 90 to 100 gal. of boiling water are added gradually. The mass then thickens into a paste. The paste is mashed with about 65 lb. of well steeped malt, and the liquid left to subside for 3 or 4 hours. It is then drained off through the perforated bottom into a fermenting back or tub. For this amount of material the back should be of about 300 gal. capacity.

The leavings left in the preparatory tub still contain considerable starch, and after they are well drained they should be mixed with from 50 to 55 gal. of boiling water. The mixture is then agitated and drained off into the fermenting back. The sediment left is again sprinkled with water, this time cold, which is drained off into the back. This completely exhausts the husks left on the upper bottom. By this process 200 lb. of potatoes should produce something over 12½ gal. of spirit.

The objection to the last method described is that the spirit so obtained is unpleasant to taste and smell, but this would probably not be an objection for industrial uses.

The spirit obtained by treating the *yam* or *sweet potato* in a similar manner is said to be far superior to that yielded by the common potato.

According to *Erfindungen und Erfahrungen*, *chicory* seems likely to become of importance as a source of alcohol. The root contains an average of 24 per cent. of substances easily convertible into sugar, and the alcohol obtained by its saccharification, fermentation, and distillation is characterised by a pleasant aromatic flavour and great purity.

Storage of Potatoes.— According to the investigations of Müller-Thurgaus, three processes take place simultaneously in the potato: Loss of water through evaporation, conversion of starch into sugar by the action of dias tatic enzymes, and destruction of the sugar through respiration, accompanied by the evolution of carbonic acid. The first and last processes cause losses, the remaining one does not. If the three processes balance, the proportional starch content is the same before and after storage. If the evaporation exceeds, the percentage of starch increases; if the respiration preponderates, it decreases. Absolute losses always take place. As respiration is less at decreasing temperatures and practically ceases at 32° F., the losses are correspondingly less the nearer the storage temperature approaches the latter point. The diastatic action, however, is affected very little by low temperatures. If the temperature falls below 28° F., the potato freezes. Frosted potatoes acquire a sweet taste, due to the formation of sugar caused by the interruption or checking of the respiratory process, while the conversion of starch into sugar continues. In storing potatoes in a falling temperature there are three possibilities: if the temperature falls slowly to 32° F., the sugar formation continues, the respiration decreases, and the tuber becomes sweet. If the temperature falls below 28° F., the potatoes freeze and remain sweet. If the temperature falls rapidly below 28° F., the potatoes freeze but do not become sweet, as there was not sufficient time to permit the formation of sugar. Potatoes are usually kept at a temperature ranging between 40° and 50° F.

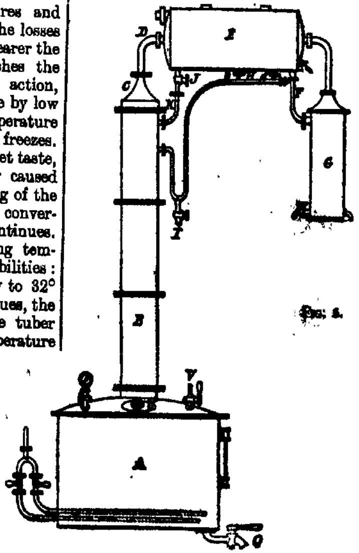


Fig. 1.

Rectification.—The product of the distillation of alcoholic liquors, termed "low wine," does not usually contain alcohol in sufficient quantity to admit of its being employed for direct consumption. Besides this, it always contains substances which have the property of distilling over with the spirit, although their boiling points, when in the pure state, are much higher than that of alcohol. These are all classed under the generic title of "fusel-oil": owing to their very disagreeable flavour and odour, their presence in spirits is extremely objectionable. In order to remove them the rough products of distillation are submitted to a further process of concentration and purification. Besides fusel-oil, they contain other substances, such as aldehyde, various ethers, etc., the boiling-points of which are lower than that of alcohol; these must also be removed, as they impart to the spirit a fiery flavour. The whole process is termed "rectification," and is carried on in a distillatory apparatus. Heat is first applied gradually in order to remove the most volatile impurities, and to concentrate them in the first portion of the distillate. When the spirit coming over possesses no objectionable odour, it is caught separately as long as it is of sufficient strength. The receiver is then changed again, and the remainder is collected apart as weak spirit which contains much fusel-oil; the first and last runnings are then mixed together and re-distilled with the next charge. When a strong spirit is required, rectification may be repeated several times. It is customary, however, with the improved apparatus of modern times, to produce at the outset spirit containing but little fusel-oil and at least 80 per cent. of alcohol; this is then purified and concentrated in the above manner, and afterwards reduced with water to the required strength.

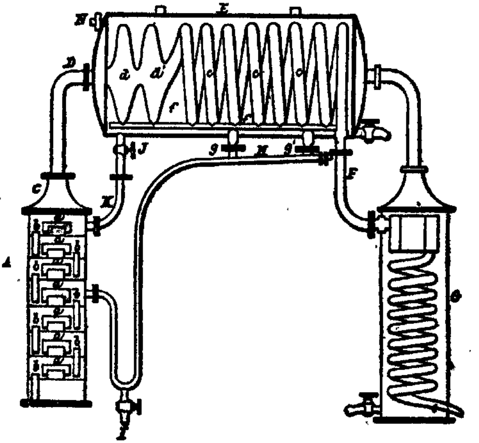


FIG. 6.

Another cause of the offensive flavour of the products of distillation is the presence of various acids which exist in all fermented liquors; they are chiefly tartaric, malic, acetic, and lactic acids. The excessive action of heat upon liquors which have been distilled by an open fire has also a particularly objectionable influence upon the flavour of the products.

The first operation in the process of rectification is to neutralise the above-mentioned acids; this is effected by means of milk of lime, which is added to the liquor in quantity depending upon its acidity; the point at which the neutralisation is complete is determined by the use of litmus paper. In the subsequent process of distillation, the determination of the exact moments at which to begin and to cease collecting the pure spirit is very difficult to indicate. It must be regulated by the nature of the spirits; some may be pure 20 or 30 minutes after they have attained the desired strength; and some only run pure an hour, or even more, after this point. The product should be tasted frequently, after being diluted with water, or a few drops may be poured into the palm of the hand, and after striking the hands together, it will be known by the odour whether the spirit be of good quality or not; these two means may be applied simultaneously.

The process of rectification is usually

carried on in the apparatus shown in Figs. 5 and 6. A is a still, ⅘ full of the spirit to be rectified. The condenser E and the cooler G are filled with water. After closing the cocks F and I the contents of the still are heated by steam, which is introduced at first slowly. The vapours of spirit given off pass above the plates *a* of the column B, and escape through C and D into the condenser E, where they are condensed on reaching the lentils *d d'*, and return in a liquid state through *f f'* and *g g'* to the upper plates of the column B. In these return pipes the liquid is volatilised and constantly recharged with alcohol to be again condensed, until the water in the condenser is hot enough to permit the lighter alcoholic vapours to pass into the coil *c*, without being reduced to the liquid state. When this is the case, the vapours pass through F into the cooler G, where they undergo complete condensation. Great care must be taken that the heat is not so great as to permit any of the vapours to pass over uncondensed, or to flow away in a hot state; and also to keep up a constant supply of water in the cooler without producing too low a temperature; the alcoholic products should run out just cold. The highly volatile constituents of the spirit come over first, that which follows becoming gradually purer until it consists of well-flavoured alcohol; after this comes a product containing the essential oils. The more impure products are kept apart from the rest and redistilled with the next charge. Some hours generally elapse before alcohol begins to flow from the cooler. The purest alcohol is obtained while its strength is kept between 92° and 96° B., and the operation is complete when the liquid flowing through the vessel marks not more than 3° or 4° B.; it is better, however, to stop the still when the backing or "faints" indicate 10° B. because the product after this point contains much fusel-oil, and is not worth collecting.

In order to cleanse the apparatus—which should be performed after each working—the still A is emptied of water by opening the cock C. The contents of the condenser are then emptied in like manner by opening the cock J, through which they flow upon the plates in the column B, and wash out essential oils which remain in them. These two cocks are then closed and the door U is removed. The water in the cooler G is then run by means of a pipe into the still A, so as partially to cover the steam-coil in the latter. After again securing the door U, a strong heat is applied, and the water in the still is well boiled, the steam evolved thoroughly cleansing all parts of the apparatus; this is continued for 15 or 20 minutes, when the heat is withdrawn and the still left to cool gradually.

The capacity of the rectifying apparatus has a good deal of influence upon both the quantity and the quality of the spirit obtained. Besides being much more difficult to manage, a small apparatus will not yield so large a proportion of spirit as a more capacious one, nor will its products be of equally good flavour. The proportion of alcohol which may be obtained from a successful rectification is very variable; it depends upon the nature of the spirit rectified, the method of extracting the sugar, and the manner of conducting the distillation; it will also be in inverse proportion to the quantity of fusel-oil contained in the raw spirit. The average loss of pure alcohol during the process of rectification is generally estimated at about 5 per cent.

Wood-alcohol [pyroligneous acid, or pyroxylic spirit] is one of the products of the dry distillation of woods, those chiefly used, stated in the order of merit, being birch, beech, elder, and oak. The seasoned and barked wood is placed in iron retorts, similar to, but larger than gas retorts, and heated to 400° to 500° F. (204½° to 260° C.) for usually 6 to 8 hours. The slower the distillation can be conducted the greater the yield of wood-alcohol, as a quick fire causes an evaporation of alcohol. The liquor from the distillation is run into pans, and left for the tarry matters to float, when they are skimmed off. The acetic acid present is neutralised by lime, and forms commercial acetate of lime. The remaining crude liquor is re-distilled, and affords crude wood alcohol. It is further concentrated by a second distillation and then rectified, to free it from tarry impurities, traces of acetic acid, and much of its characteristic odour. (For a full account of wood distillation the reader is referred to Spons' 'Encyclopædia,' Part 4.)

Denatured Alcohol or Methylated Spirit.—This is simply alcohol which has been so treated as to spoil it as a beverage or medicine (or drink of any kind), and prevent its use in any manner except for industrial purposes. The following information is extracted from F. B. Wright's practical handbook on the "Distillation of Alcohol" (E. & F. N. Spon. Ltd.).

The common form of alcohol known as "denatured spirit" or "methylated spirit" consists of alcohol to which one tenth of its volume of wood alcohol (methyl alcohol), or other denaturising agent, has been added, for the purpose of rendering the mixture undrinkable through its offensive odour and taste. Methylated spirit being sold duty free, is applied by chemical manufactures, varnish makers, and many others, to a variety of uses, to which, from its greater cost, duty-paid spirit is commercially inapplicable. It has often been attempted to separate the wood spirit from the alcohol, and thus to obtain pure alcohol from the mixture, but always unsuccessfully, as, although the former boils at a lower temperature than the latter, when boiled they both distil over together, owing probably to the difference of their vapour densities.

De-naturing may be accomplished in many ways.

In England a mixture suitable for industrial purposes, but unfit for any other use, is made by mixing 90 per cent. of ethyl alcohol (alcohol made from grain, potatoes, beets, etc.), with 10 per cent. of methyl or "wood alcohol." Under the new law the proportion of wood alcohol is cut to 5 per cent.

In Canada "methylated spirits," as it is known, is composed of from 25 per cent. to 50 per cent. of wood alcohol mixed with ethyl alcohol. This proportion of wood alcohol is far more than is necessary, or than is necessary in any other country.

In Germany, the de-naturing law passed in 1887 was so framed as to maintain the high revenue tax on alcohol intended for drinking, but to exempt from taxation such as should be de-natured and used for industrial purposes. De-naturing, as stated, is accomplished by mixing with the spirit a small proportion of some foreign substance, which, while not injuring its efficiency for technical uses, renders it unfit for consumption as a beverage. The de-naturing substances employed depend upon the use to which the alcohol is to be subsequently applied. They include pyridin, picolin, benzol, toluol, and xylol, wood vinegar, and several other similar products. As a result of this system Germany produced and used last year 30,642,720 gal. of de-natured spirits, as compared with 10,302,630 gal. used in 1886, the last year before the enactment of the present law.

The following are some of the other de-naturants used in Germany: Camphor, oil of turpentine, sulphuric ether, animal oil, chloroform, iodoform, ethyl bromide, benzine, castor oil, lye.

In France the standard mixture consists of:

15 litres of wood alcohol.
½ litre of heavy benzine.
1 gram malachite green.

An illustration of de-naturing on a large scale is given by the methods and operations of a large London establishment. On the ground floor are 4 large iron tanks holding about 2500 gal. each. On the next floor are casks of spirit brought under seal from the bonded warehouse. On the third floor are the wood alcohol tanks, and on the fourth floor cans of methylating materials. On the fourth floor the covers to the wood alcohol tanks were removed (these tank covers were flush with that floor) and the contents gauged and tested. The quantity to be put into the tanks on the first floor was run off through pipes connecting with the first-floor tanks and the upper tanks relocked. Then going to the second floor, each cask of the grain spirit was gauged and tested, and the tank covers, which were flush with the floor, were removed and the casks of the grain spirit were run into the tanks below. The mixture was then stirred with long-handled wooden paddles, and the tank covers replaced, and the material was ready for sale free of tax. The mixture was 10 per cent. wood alcohol and 90 per cent. ethyl alcohol made from molasses, and was what is known as the ordinary methylating spirit used for manufacturing purposes only and used under bond. The completely de-natured spirit is made by adding to the foregoing ½ of 1 per cent. of benzine. This benzine prevents re-distillation.

The use of de-natured alcohol as a fuel has yet to be fully developed. Although alcohol has only about half the heating power of kerosene or gasoline, gallon for gallon, yet it has many valuable properties which may enable it to compete successfully in spite of its lower fuel value. In the first place it is very much safer. Alcohol has a tendency to simply heat the surrounding vapours and produce currents of hot gases, which are not usually brought to high enough temperature to inflame articles at a distance. It can be easily diluted with water, and when it is diluted to more than one half it ceases to be inflammable. Hence it may be readily extinguished; while burning petrol, by floating on the water, simply spreads its flame when water is applied to it. Although alcohol has far less heating capacity than petrol, the best experts believe that it will devolop a much higher percentage of efficiency in motors than does petrol. Since petrol represents only about two per cent. of the petroleum which is refined, its supply is limited and its price must constantly rise, in view of the enormous demand made for it for automobiles and petrol engines in general. This will open a new opportunity for de-natured alcohol. Industrial alcohol is now used in Germany in small portable lamps, which give it all the effects of a mantle burner heated by gas. The expense for alcohol is only about two-thirds as much per candle-power as is the cost of kerosene. Even at 1*s.* to 1*s.* 3*d.* per gallon de-natured alcohol can successfully compete with petroleum as a means of lighting.

Objection has been made to the use of alcohol in automobiles and other internal-explosive engines, that it resulted in a corrosion of the metal. This is vigorously denied by the advocate of alcohol fuel, and the denial is backed by proofs of the use of alcohol in German engines for a number of years without any bad results.

Alcohol Barrels. — Barrels or casks designed to be filled with alcohol, may be made tight by the application of the following solution: Dissolve in a water bath 1 lb. of leather scraps and 1 oz. of oxalic acid, in 2 lb. of water and dilute gradually with 3 lb. of warm water. Apply this solution to the inside of the barrel, where, by oxidation, it will assume a brown colour, and become insoluble in alcohol. This coat closes all the pores of the wood, and does not crack or scale off.

ALCOHOLOMETRY.

ALCOHOLOMETRY is the name given to a variety of methods of determining the quantity of absolute alcohol contained in spirituous liquors. It will readily be seen that a quick and accurate method of making such determinations is of the very utmost importance to those who are engaged in the liquor traffic, since the value of spirit depends entirely upon the percentage of alcohol which it contains. When alcoholic liquors consist of simple mixtures of alcohol and water the test is a simple one, the exact percentage being readily deducible from the specific gravity of the liquor, because to a definite specific gravity belongs a definite content of alcohol; this is obtained either by means of the *specific gravity bottle*, or of hydrometers of various kinds, specially constructed.

The measurement of the percentage of absolute alcohol in spirituous liquors is almost invariably expressed in volume rather than weight, owing to the fact that such liquors are always sold by volume. Nevertheless, the tables referred to above show the percentage of spirit both by volume and weight.

The standard liquor known as *proof spirit* contains 49·5 per cent. by weight, and 57·27 per cent. by volume, of absolute alcohol; it has a specific gravity of 0·9186 at 60° F. The strength and therefore the value of spirituous liquors is estimated according to the quantity by volume of anhydrous spirit contained in the liquor with reference to this standard. Thus the expression "20 *per cent. overproof*," "20 *per cent. underproof*," means that the liquor contains 20 volumes of water for every 100 volumes over or under this fixed quantity, and that in order to reduce the spirit to *proof*, 20 per cent. of water by volume, must be subtracted or added, as the case may be. Any hydrometer constructed for the measurement of liquids of less density than water may be employed. That known as "Syke's" is most commonly used for alcoholometric purposes. It is shown in Fig. 7, and consists of a spherical brass ball A, to which are fixed two stems; the upper one B. is also of brass, flat, and about 3½ in. in length; it is divided into 10 parts, each being subdivided into 5, and the whole being numbered as shown in the figure. The lower stem C is conical, and slightly more than an inch long; it terminates in a weighted bulb D. A series of circular weights, of the form shown in the figure, accompany the instrument; these are slipped upon the top of the lower stem C, and allowed to slip down until they rest upon the bulb D. The instrument is used in the following way: It is submerged in the liquor to be tested until the whole of the upper stem is under the surface, and an idea is thus gained of the weight that will be required to *partly* submerge the stem. This weight is added, and the hydrometer again placed in the liquor. The figure on the scale to which the instrument has sunk when at rest is now observed, and added to the number on the weight used, the sum giving, by reference to the tables, the percentage by volume of absolute alcohol above or below the standard quantity.

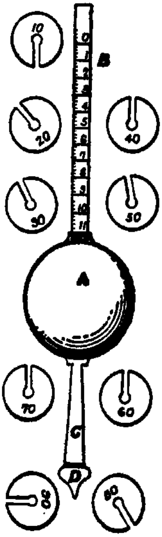


FIG. 7.

In exact estimations, the temperature of the liquor tested must be carefully registered, and the necessary corrections made. In Jones' hydrometer, which is an improvement upon

Syke's, a small spirit thermometer is attached to the bulb, and by noting the temperature of the liquor at the time of the experiment, and referring to the tables accompanying the instrument, the strength is found at once without the need of calculation.

Dica's hydrometer is used in America. It is very similar to Jones' instrument above described. It is of copper, has a stem fitted to receive brass poises, a thermometer, a graduated scale, etc.

In Europe, Gay-Lussac's hydrometer and tables are chiefly used for alcoholometric testing. This instrument is precisely similar in construction to those of Twaddell and Baume. On the scale, zero is obtained by placing it in pure distilled water at 59° F., and the highest mark, or 100, by placing it in pure alcohol at the same temperature, the intermediate space being divided into 100 equal divisions, each representing 1 per cent. of absolute alcohol. The correction for temperature, as in the above cases, is included in the reference tables.

Another hydrometer, used in France for alcoholometric determinations, is Cartier's. In form it is precisely similar to Baume's hydrometer. Zero is the same in both instruments, but the point marked 30° in Cartier's is marked 32° in Baume's, the degrees of the latter being thus diminished in the proportion of 15 or 16. Cartier's hydrometer is only used for liquids lighter than water.

The above hydrometric methods can be safely employed only when the spirit tested contains a very small amount of solid matter, since, when such matter is contained in the liquor in quantity, the density alone cannot possibly afford a correct indication of its richness in alcohol. Many methods have been proposed for the estimation of alcohol in liquor, containing saccharine colouring and extractive matters, either in solution or suspension. Undoubtedly the most accurate of these, though at the same time the most tedious, is to subject the liquor to a process of distillation by which a mixture of pure alcohol and water is obtained as the distillate. This mixture is carefully tested with the hydrometer, and the percentage of alcohol in it determined by reference to the tables as above described; from this quantity and the volume of the original liquor employed the percentage by volume of alcohol in that liquor is readily found. The condensing arrangement must be kept perfectly cool, if possible in a refrigerator, as the alcohol in the distillate is very liable to be lost by re-evaporation. When great accuracy is desired, and time is at the operator's disposal, the above method is preferable to all others.

It is performed in the following manner: 300 parts of the liquor to be examined are placed in a small still, or retort, and exactly one-third of this quantity is distilled over. A graduated glass tube is used as the receiver, in order that the correct volume may be drawn over without error. The alcoholic richness of the distillate is then determined by any of the above methods, and the result is divided by 3, which gives at once the percentage of alcohol in the original liquor. The strength at proof may be calculated from this in the ordinary way.

If the liquor be acid, it must be neutralised with carbonate of soda before being submitted to distillation. From 8 to 10 per cent. of common salt must be added, in order to raise the boiling point, so that the whole of the spirit may pass over before it has reached the required measure. In the case of the stronger wines it is advisable to distil over 150 parts and divide by 2 instead of 3. If the liquor be stronger than 25 per cent. by volume of alcohol, or above 52 to 54 per cent. under-proof, an equal volume of water should be added to the liquid in the still, and a quantity distilled over equal to that of the sample tested, when the alcoholic strength of the distillate gives, without calculation, the correct strength required. If the liquor be stronger than 48 to 50 per cent. under-proof, three times its volume of water must be added, and the process must be continued until the volume of the distillate is twice that of the sample originally taken. In each case the proportionate quantity of common salt must be added.

For the estimation of alcohol in wines, liquors etc., the following method may be employed: A measuring flask is filled up to a mark on its neck with the liquor under examination, which is then transferred to a retort: the flask must be carefully rinsed out with distilled water, and the rinsings added to the liquor in the retort. About two-thirds are then drawn over into the same measuring flask, and made up to its previous bulk with distilled water, at the same temperature as that of the sample before distillation. The strength is then determined by means of Syke's hydrometer, and this, if under-proof, deducted from 100, gives the true percentage of proof-spirit in the wine.

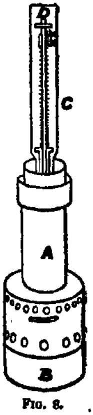


FIG. 8.

A quick, if not always very exact, method consists in determining the point at which the liquor boils. The boiling point of absolute alcohol being once determined, it is obvious that the more it is diluted with water the nearer will boiling point of the mixture approach that of water; moreover, it has been proved that the presence of saccharine and other solid matters has but an almost inappreciable effect upon this point. Field's alcoholometer, since improved by Ure, is based upon this principle. It is shown in Fig. 8, and consists, roughly speaking, of a cylindrical vessel A, to contain the spirit; this vessel is heated from beneath by a spirit lamp, which fits into the case B. A delicate thermometer C, the bulb of which is introduced into the spirit, is attached to a scale divided into 100 divisions, of which each represents one degree over- or under-proof. This method is liable to several small sources of error, but when a great many determinations have to be made, and speed is an object rather than extreme accuracy, this instrument becomes exceedingly useful. It does not answer well with spirits *above* proof, because the variations in their boiling points are so slight as not to be easily observed with accuracy. But for liquors under-proof, and especially for wines, beer, and other fermented liquors, it gives results closely approximating to those obtained by distillation, and quite accurate enough for all ordinary purposes. Strong liquors should therefore be tested with twice their bulk, and commercial spirits with an equal bulk, of water, the result obtained being multiplied by two or three, as the case may be.

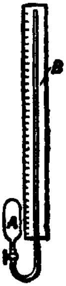


FIG. 9.

Another very expeditious, but somewhat rough, method was invented by Geisler. It consists in measuring the tension of the vapour of the spirit, by causing it to raise a column of mercury in a closed tube. The very simple apparatus is shown in Fig. 9. A is a small glass bulb, fitted with a narrow tube and stop-cock. This vessel is completely filled with a spirit, and is then screwed upon a long, narrow tube B, bent at one end and containing mercury. This tube is attached to a graduated scale showing the percentage of absolute alcohol above or below proof. To make the test the cock is opened, and the bulb, together with the lower part of the tube, is immersed in boiling water, which gradually raises the spirit to its boiling point. When this is reached, the vapour forces the mercury up the tube, and when stationary, the degree on the scale to which it has ascended gives directly the percentage of alcohol.

Another method, which is not to be relied on for very weak liquors, but which answers well for cordials, wines and strong ales, is that known as Brand's method. The liquor is poured into a long, narrow glass tube, graduated centesimally, until it is half-filled. About 12 to 15 per cent. of subacetate of lead, or finely powdered litharge, is then added, and the whole is shaken until all the colour is destroyed. Powdered anhydrous carbonate of potash is next added until it sinks undissolved in the tube, even after prolonged agitation. The tube is then allowed to rest, when the alcohol is observed to float upon the surface of the water in a well-defined layer. The quantity read off on the scale of the tube and doubled, gives the percentage by volume of alcohol in the original liquid. The whole operation may be performed in about five minutes, and furnishes reliable approximative results. In many cases it is unnecessary to add the lead salt for the purpose of decolorising the liquid.

ALKALIMETRY.

(*See also* ACIDIMETRY.)

ALKALIMETRY is the determination of the quantity of real alkali in alkaline salts and solutions. As in the case of acidimetry, p. 6, the determinations may be made either by gravimetric or by volumetric analysis.

Gay-Lussac's method is based upon a titrated solution of carbonate of soda with a corresponding solution of sulphuric acid. Instead of the carbonate it is preferable to use caustic soda, in order to avoid the objectionable interference caused by the presence of carbonic acid. The indicator employed is a solution of litmus, made by digesting about 10 grm. of litmus in ½ litre of distilled water for a few hours; the clear liquid is decanted and kept in a small, tightly-corked wash-bottle, from which a few drops can be expelled when required. A very small quantity of dilute nitric acid may be advantageously added to the solution, in order to produce a violet colour, which increases the sensibility of the indicator. The standard solution of sulphuric acid contains 49 grm. of real sulphuric acid per litre, and may be made in the following way: 30 cc. of the pure acid, 1·840 sp. gr., is diluted with water in a beaker, and the mixture is left to stand; when perfectly cool, it is washed into a litre flask, and diluted to the containing-mark. The solution is next tested with a standard solution of carbonate of soda, containing 53 grm. of pure carbonate to the litre, carefully weighed and measured; 10 cc. of this latter solution is placed in a beaker with a little distilled water and a few drops of the litmus solution, and the acid is run in carefully and slowly until the point of saturation is reached. If more than 10 cc. be required the solution is too weak; if less, it is too strong, and it must either be strengthened or diluted, as the case may be, until 10 cc. of each solution *exactly neutralise each other*. In order to insure perfect accuracy, large quantities of the two substances, say 50 or 100 cc., may be employed, when the difference, if any, will be more readily detected. If caustic soda be used instead of carbonate, about 42 grm. is to be dissolved in water (about 800 cc.); the above test is applied, and small quantities of water are added until equal volumes exactly correspond. All these solutions are kept in tightly stoppered bottles.

The method of procedure is as follows:—The necessary quantity of alkali being weighed or measured, as the case may be, it is diluted with distilled water in a flask, and enough litmus is added to produce a distinct, but not too deep, blue colour. The acid from the burette is then run in until the contents of the flask have been changed to a bright red colour. In order to expel the carbonic acid, the flask is boiled until the blue colour reappears; the acid solution must now be run in, a few drops at a time, with continued boiling, until, by the addition of a single drop, a distinct pink colour is produced. In order to obtain a very accurate result, it is well to run in an excess of acid, boil the liquid well, and then add, drop by drop, the standard alkaline solution until the liquid suddenly changes from pink to violet-blue. The quantity of the alkaline solution required to effect this change is subtracted from the volume of acid originally run in, and the exact volume of standard acid required to neutralise the amount of alkali previously taken from analysis is thus determined at once.

The converse of this process may be applied to the estimation of the amount of acid contained in acid liquids or mixtures (see Acidimetry).

Mohr recommends the use of oxalic acid instead of sulphuric or hydrochloric, because it is more readily weighed than a liquid, and because its solution may be kept for a much longer period than these without undergoing change in strength. The weight required is 63 grm. per litre of water.

In making determinations of the quantity of alkali contained in samples of crude carbonate of potash and soda by gravimetric [weight] analysis, the apparatus used in acidimetry, Fig. 3, p. 6, may be employed. The weighed carbonate is dissolved in warm water in the flask A, and a quantity of acid more than sufficient to neutralise the alkali is placed in the short tube in the interior. The apparatus is then weighed, and the tube *d* closed by a plug of wax; the flask is tilted gently, so as to cause the acid to flow into the flask upon the carbonate. Carbonic acid is thus evolved, and the apparatus should be gently warmed until the evolution of gas completely ceases. When this is the case, the plug is removed, air is drawn through, and the whole is again weighed. The loss indicates the quantity of carbonic acid evolved, from which the amount of real carbonate contained in the sample may be calculated at once. The acidity of the solution, at the conclusion of the test, should be determined by adding a drop of litmus solution; if it be not acid, more acid must be added and the operation repeated.

Fresenius and Will's apparatus, shown in Fig. 4, p. 6, may also be employed in making alkalimetrical estimations the same as in acidimetry. The alkali to be tested is carefully weighed, and dissolved in water in the flask A; concentrated sulphuric acid is placed in the flask B, and the apparatus is accurately weighed. After closing the end of the tube *c*, suction is applied to the tube *a*, so as to draw over a small quantity of air from A into B through the tube *b*; on withdrawing the lips, the pressure of air forces a little of the acid over into A, by which means the alkali is decomposed. This is continued until the evolution of carbonic acid ceases, when heat is applied gently for a few moments. Air is then drawn through, and the apparatus is cooled and weighed. The loss in weight gives the amount of carbonic acid evolved, as in the previous case.

ALKALOIDS.

THE following are some of the general methods of preparing alkaloids:—

(1) *Base insoluble in water, non-volatile, and existing in the plant in an insoluble form.* The bruised plant is boiled or macerated in water acidulated with hydrochloric or acetic acid, and the liquor, after filtration, is neutralised with an alkali (ammonia, potash, lime, or magnesia); the resulting precipitate is purified by re-

solution in dilute acid, digestion with a little animal charcoal, and subsequent crystallisation, or reprecipitation with an alkali; or the first precipitate is purified by dissolving once, or, if necessary, several times in boiling alcohol, which yields the pure alkaloid either on cooling or by evaporation.

(2) *Base insoluble in water and non-volatile, but existing in the plant as a soluble salt.* The bruised or sliced plant is either boiled or macerated in water, and the filtered liquor is precipitated and otherwise treated as in (1).

(3) *Base soluble in water and non-volatile.* An infusion made with very dilute acid, hydrochloric or acetic, is concentrated by gentle heat, and the residual liquor is treated with potash (or concentrated solution of ammonia) and ether conjointly; after repose, the ethereal solution is decanted and evaporated. For those alkaloids which are insoluble in ether (as morphine and cinchonine), the previous process may be adopted.

(4) *Base both soluble in water and volatile.* The vegetable, in a bruised or divided state, or its extract, is alkalised with potash and distilled; the distillate is neutralised with dilute oxalic or sulphuric acid and carefully evaporated to dryness; the residue is next digested in alcohol, and the resulting tincture agitated with potash and ether, the former being in quantity just sufficient to seize on all the acid; lastly, the ethereal solution thus formed, on careful evaporation, leaves the alkaloid nearly pure. It may be further purified by cautious distillation.

As some of the alkaloids are soluble in excess of the alkaline precipitant, over-saturation should be carefully avoided, or the precipitant may be used under the form of carbonate or bicarbonate. When lime and magnesia are employed, they are boiled for a few minutes with the solution.

Aconitine.—(1) This alkaloid is obtained from the leaves of the *Aconitum Napellus.* The leaves are infused in alcohol, and the solution is treated with milk of lime, which liberates the alkaloids in solution. To the filtered liquid is added a little sulphuric acid, and the precipitated sulphate of lime is filtered off. The filtrate is evaporated until free from alcohol, when the aconitine is precipitated by an alkaline carbonate. This precipitate is re-dissolved in alcohol and the solution is decolorised by animal black, and evaporated to dryness. The residue is re-dissolved in sulphuric acid, and precipitated anew with an alkaline carbonate; the precipitate thus obtained yields pure aconitine on treatment with ether. It is deposited from this solution in a white powder, or sometimes in the form of a compact, transparent, vitreous mass.

(2) Aconite root, in coarse powder, 14 lb.; rectified spirit, distilled water, solution of ammonia, pure ether, diluted sulphuric acid, of each a sufficiency. Pour upon the aconite root 3 gal. of the spirit, mix well, and heat until ebullition commences; then cool and macerate for 4 days. Transfer the whole to a displacement apparatus, and percolate, adding more spirit, when requisite, until the root is exhausted. Distil off the greater part of the spirit from the tincture, and evaporate the remainder over a water-bath, until the whole of the alcohol has been dissipated. Mix the residual extract thoroughly with twice its weight of boiling distilled water, and when it has cooled to the temperature of the atmosphere, filter through paper. To the filtered liquid add solution of ammonia in slight excess, and heat gently over a water-bath. Separate the precipitate on a filter and dry it. Reduce this to coarse powder, and macerate in successive portions of the pure ether with frequent agitation. Decant the several products, mix and distil off the ether until the extract is dry. Dissolve the dry extract in warm, distilled water acidulated with the sulphuric acid; and, when the solution is cold, precipitate it by the cautious addition of solution of ammonia diluted with 4 times its bulk of distilled water.

Wash the precipitate on a filter with a small quantity of cold distilled water, and dry it by slight pressure between folds of filtering paper. (Cooley.)

Atropine.—Atropine is an alkaloid extracted from the root of the deadly nightshade (*Atropa Belladonna*). The following, according to Cooley, are the principal recognised methods of preparing the alkaloid :—

(1) Belladonna root, recently dried, and in coarse powder, 2 lb. ; rectified spirit, 10 pints ; slaked lime, 1 oz. ; diluted sulphuric acid, carbonate of potash, of each a sufficiency ; chloroform, 3 fl. oz. ; purified animal charcoal, a sufficiency ; distilled water, 10 fl. oz. Macerate the root in 4 pints of the spirit, for 24 hours, with frequent stirring. Transfer to a displacement apparatus, and exhaust the root with the remainder of the spirit by slow percolation. Add the lime to the tincture placed in a bottle, and shake them occasionally. Filter, add the diluted sulphuric acid in very feeble excess to the filtrate, and filter again. Distil off $\frac{3}{4}$ of the spirit, add to the residue the distilled water, evaporate at a gentle heat, but as rapidly as possible, until the liquor is reduced to $\frac{1}{8}$ of its volume and no longer smells of alcohol ; then let it cool. Add very cautiously, with constant stirring, a solution of carbonate of potash, so as nearly to neutralise the acid, care, however, being taken that an excess is not used. Set to rest for 6 hours, then filter, and add carbonate of potash in such quantity that the liquid shall acquire a decided alkaline reaction. Place in a bottle with the chloroform ; mix well by frequently repeated brisk agitation, and pour the mixed liquids into a funnel furnished with a glass stop-cock. When the chloroform has subsided, draw it off by the stop-cock, and distil it on a water-bath from a retort connected with a condenser. Dissolve the residue in warm rectified spirit ; digest the solution with a little animal charcoal ; filter, evaporate, and cool until colourless crystals are obtained.

(2) Expressed juice of belladonna is evaporated over a water-bath to the consistence of an extract, and then triturated in a marble or porcelain mortar with a strong solution of caustic potash ; the resulting mass is digested and well agitated for some time, at the temperature of 75° to 80° F. (24° to 27° C.), with benzole, q. s. ; and after repose, the benzole solution is carefully separated, and its volatile hydrocarbon is distilled off by the heat of a water-bath ; the residuum in the retort is now exhausted with water acidulated with sulphuric acid, and the resulting "acid solution," after filtration, precipitated with carbonate of soda ; the precipitate is crude atropine, which is collected on a filter, pressed between folds of blotting paper, and dried ; after which it is purified by one or more re-solutions in alcohol, and crystallisations, which may or may not be modified in the manner noticed. The proportion of potash should be about 1 dr. to every quart of the expressed juice. An excellent and economical process. The product is 0·3 to 4 per cent. of the weight of the plant from which the juice has been obtained.

(3) Belladonna root (fresh-dried and coarsely powdered) is exhausted by alcohol (0·882 sq. gr.) ; slaked lime (1 part for every 24 of the dried root employed) is then added to the tincture, and the whole digested, with agitation, for 24 hours ; sulphuric acid is next added, drop by drop, to slight excess, and, after filtration, rather more than half the spirit is removed by distillation ; a little water is now added to the residue and the remainder of the alcohol evaporated as quickly as possible by a gentle heat ; after again filtering, the liquid is reduced by further evaporation to the $\frac{1}{12}$ part of the weight of the root employed, and a concentrated solution of potash dropped into the cold liquid (to throw down a dark greyish brown matter), carefully avoiding excess, or rendering the liquid in the slightest degree alkaline ; in a few hours, the

liquid is again filtered and carbonate of potash added as long as a precipitate (atropine) falls; after a further interval of 12 to 24 hours, this precipitate is collected and drained in a filter, and after pressure between folds of blotting-paper, dried by a very gentle heat. It is purified by making it into a paste with water, again squeezing it between the folds of blotting-paper, drying it, re-dissolving it in 5 times its weight of alcohol, decolorising it with pure animal charcoal, distilling off greater part of the alcohol, and evaporation and crystallisation by a very gentle heat; or only about ½ the spirit is distilled off, and 3 or 4 times its volume of water gradually agitated with it, the resulting milky liquid being then heated to boiling, and allowed to cool very slowly, when nearly the whole of the atropine crystallises out after a few hours. The same may be effected by at once agitating 6 or 8 volumes of water with the alcoholic solution, and setting aside the mixture for 12 to 24 hours, by which time the crystallisation will be completed. This process originated with Soubeiran, was improved by Mein, and subsequently, with slight modifications, adopted by Liebig. The product is about 0·3 per cent. of the weight of the root operated on.

(4) The filtered tincture is precipitated with iodine dissolved in an aqueous solution of iodide of potassium; the resulting ioduretted hydriodate of atropine is decomposed by zinc-and-water; the metalic oxide is separated by means of carbonate of potash; and the alkaloid thus obtained is dissolved in alcohol, and crystallised. (Bouchardat and Cooper.)

(5) The dry leaves of belladonna are gently boiled for two hours in distilled water just sufficient to cover them, and the resulting decoction is strained through a coarse cloth into a large precipitating jar; this process is repeated with a second quantity of distilled water, and the two decoctions are mixed; concentrated sulphuric acid is now added in the proportion of 2 dr. to every lb. of leaves operated on, by which the vegetable albumen of the decoction is precipitated, and the liquid becomes clear and sherry-coloured; the clear liquor is decanted or siphoned off, and if necessary, filtered; the filtrate is decomposed by either passing a stream of gaseous ammonia through it, or by suspending in it a lump of carbonate of ammonia. The effect is that the liquid turns black, and crystals of atropine are slowly formed and deposited. At the expiration of a day or two, the supernatant mother-liquid is removed with a siphon, and the crystals are thrown on a filter to drain and dry. It may be purified by re-solution and crystallisation. 1 lb. of leaves yields 40 gr., or at the rate of 0·57 per cent. (Luxton.)

(6) To 1 qt. of the crystallised juice of the plant (previously heated to coagulate its albumen, filtered, and allowed to cool) is added 1 dr. caustic potash and 1 oz. chloroform; the whole is then agitated well, and after ½ hour's repose, the supernatant liquor is poured from the discoloured chloroform, which, after being washed with distilled water as long as it gives any colour to it, is placed in a small retort, and the chloroform distilled off by a water-bath; the residue is dissolved in a little water acidulated with sulphuric acid, and precipitated by potash carbonate in slight excess; the precipitate is re-dissolved in alcohol, and the solution, by spontaneous evaporation, yields crystals of atropine. (Rabourdin.)

(7) The expressed juice of the fresh, or watery extract of the dry plant, is treated with caustic soda in slight excess, and agitated with 1½ times the volume of ether; the atropine taken up by the ether is re-deposited after repose for some time, and purified by repeating the treatment with fresh ether as often as necessary. (Ure.)

(8) Freshly precipitated hydrate of magnesia is added to the coagulated and filtered expressed juice, and the mixture evaporated to dryness as

quickly as possible in a water-bath; the residue is pulverised and digested in strong alcohol, and the clear liquid allowed to evaporate spontaneously. The crystals may be purified by repeated re-solutions in alcohol.

(9) The following improved process is recommended by A. W. Gerrard, who notices several objections to preceding ones. Pack 1000 grm. of well powdered belladonna leaf or root in a percolator, and allow it to macerate 24 hours with 1000 c.c. of 84 per cent. alcohol; now add in parts of 250 c.c. at intervals of about 4 hours, another 1000 c.c. of alcohol; when percolation ceases, displace with water, recover the alcohol by distillation, and treat the extract with 5 times its volume of water; carefully separate the resin and fatty matter, and wash it twice, mixing all the washings; evaporate them to 300 c.c. and add a good excess of ammonia; expose in a shallow dish for some hours that excess of ammonia may volatilise; now shake well with an equal volume of ether, separate the ether, and withdraw the atropine from it by shaking with a small volume of water and repeated additions of acetic acid. Working in this way, the ether may be used continuously to extract the mother-liquor until it is exhausted. The acetic solution of atropine is now shaken with and filtered through a little animal charcoal, concentrated to a small volume, treated again with ammonia, and dissolved out a second time with ether. Allowing the ether to spontaneously evaporate, the atropine will separate in exceedingly fine filamentous crystals of a satiny lustre and almost white. Two more crystallisations will render them quite white. In conducting this process, it is important to remove the whole of the alcohol from the tincture, also to employ ether free from alcohol. (Pharm. Journ.)

Berberine.—Berberine exists in the root of the common barberry (*Berberis vulgaris*), in the calumba root of India (*Menispermum palmatum*), and in the calumba wood of Ceylon (*M. fenestratum*). It is prepared as follows:—

(1) A soft watery extract of the root or wood is digested in rectified spirit, with trituration, as long as anything is taken up; the resulting tincture, after repose, is filtered, and the alcohol is gradually distilled off until the residue has the consistence of a thin syrup. The crystals which form as the liquid cools are drained in a funnel, washed with a few drops of ice-cold water, pressed dry in blotting paper, and then purified by solution and crystallisation, first in rectified spirit, and then in distilled water.

(2) The root or wood, coarsely powdered, is digested in rectified spirit, and treated as in (1).

Brucine.—Brucine is contained in *Brucia antidysenterica*, St. Ignatius bean and *Strychnos Nux vomica* (along with strychnine). It is generally prepared from the latter plant, which is much cheaper. The powdered nuts are treated with very dilute, boiling sulphuric acid, and expressed. The acid is next saturated with excess of milk of lime, by which sulphates of lime, strychnine, and brucine are thrown down. The precipitate is collected on a filter, and dried, and then treated with boiling alcohol (·850 sq. gr.), which dissolves the two alkaloids. The liquid is filtered while hot, and in cooling deposits the greater part of the strychnine. The brucine remains in solution, and may be obtained by evaporation. They are both purified by repeated crystallisation in alcohol.

Calumbine.—Calumbine is prepared from calumba root (*Menispermum palmatum*) by the following methods:—

(1) Digest the coarsely powdered root in water acidulated with acetic acid; express, filter, boil to ½, again filter, add calcium carbonate in slight excess, and evaporate to dryness in a water-bath; powder the residue, and digest in boiling alcohol; it will deposite crystals of calumbine on cooling.

(2) Evaporate tincture of the root

(made with rectified spirit) to dryness; dissolve residue in water, and agitate the solution with equal bulk of ether; after short repose, decant the ethereal portion, distil off most of the ether, and set the liquid aside to crystallise. (Wittstöck.)

(3) The powdered root is covered with a 2 to 3 per cent. solution of oxalic acid for some hours, and the resulting extract is neutralised with ammonia, which takes up the calumbic acid, and leaves the calumbine pure. (Alessandri.)

Cascarilline.—Cascarilline may be prepared from the bark of *Croton Cascarilla* or *C. Eleutheria* by the following processes :—

(1) The bark is exhausted with cold water by percolation, precipitated with lead acetate, and the filtrate treated with sulphuretted hydrogen; the filtered liquid, after agitation with animal charcoal, and filtration, is gently evaporated to dryness. The powder is re-dissolved in boiling alcohol, and crystallised by very slow or spontaneous evaporation. (Duval.)

(2) A quantity of coarsely powdered cascarilla bark is covered with a 2 to 3 per cent. solution of oxalic acid and allowed to stand for 12 hours, the mixture being frequently shaken. At the expiration of this period, the temperature of the mixture is gradually raised to 140° F. (60° C.), after which it is allowed to cool. Lastly, the liquid is filtered and the marc well pressed. The filtrate is then saturated with ammonia, and evaporated at a low temperature to ¾ of its bulk. The liquid is again allowed to cool, and a deposit separates; if any has been formed. The liquid is poured into a flask containing pure ether, the whole being shaken for some time. After being allowed to stand for 3 hours or more, the ethereal solution is poured off and distilled, so as to recover the greater part of the ether. The evaporation is completed spontaneously in a current of air, without the application of heat, the result being pure white cascarilline. The ethereal solution contains a small quantity of essential oil, nearly the whole of which passes over during the process of distillation; but this in no way prevents the ether from being used for the separation of another batch of the alkaloid.

Colchicine is obtained from the seeds of the meadow saffron (*Colchicum autumnale*) by the following process: Macerate the bruised seeds in boiling alcohol, add magnesia to throw down the alkaloid, digest the precipitate in boiling alcohol, and filter. By cautious evaporation, colchicine will be deposited, and may be purified by re-solution and crystallisation in alcohol.

Morphine is the most important alkaloid obtained from opium, itself a product of several species of poppy (*Papaver*). Cooley gives the following 4 methods of preparing morphine :—

(1) Turkey opium (cut into thin slices), 1 lb., is macerated for 24 hours in 1 qt. water, and the liquid portion is decanted; the residuum is macerated for 12 hours with a second quart of water, and the process is repeated with a third quart of water, after which the insoluble portion is subjected to strong pressure; the mixed liquids are evaporated by water or steam heat to a pint, and filtered through calico; to the filtrate is added a solution formed of 6 dr. calcium chloride, dissolved in 4 fl. oz. distilled water, and the liquid is further evaporated until it is so far concentrated that nearly the whole of it becomes solid on cooling; this is enveloped in a couple of folds of strong calico, and subjected to powerful pressure, the dark liquid which exudes being preserved for subsequent use; the squeezed cake is next treated with about ½ pint of boiling water and the undissolved portion is washed on a paper filter; the filtered solution is again evaporated, and the solid portion thus obtained submitted to pressure as before; if the product is not quite white, this process is repeated a third time; the squeezed cake is now dissolved in 6 fl. oz. of boiling water, and

the solution filtered through animal charcoal (if necessary); to the clear solution is added ammonia in slight excess; the crystalline precipitate, which forms as the liquid cools, is collected on a paper filter, washed with cold distilled water, and, lastly, the filter is transferred to a porous brick, in order that the morphine which it contains may become dry. (From the liquids reserved from the expressions, more morphine may be obtained by dilution with water, precipitation with ammonia, re-solution in boiling water, and treatment with a little animal charcoal, etc., as before.)

(2) Hydrochlorate of morphine, 1 oz., is dissolved in 1 pint distilled water, and 5 fl. dr. (or q. s.) ammonia previously diluted with 1 fl. oz. water is added, with agitation; the precipitate is well washed in distilled water, and dried by a gentle heat. By a similar process, morphine may be obtained from its other salts.

(3) A cold aqueous infusion of opium is precipitated with carbonate of sodium in excess; the precipitate is washed, first with cold water, and then with cold alcohol of ·85 sq. gr.; the residue is dissolved in weak acetic acid; the solution is filtered through animal charcoal, and precipitated with ammonia; the precipitate is again washed with cold water, dissolved in alcohol, and crystallised. A good process where spirit is cheap. (Merck.)

(4) Opium, 4 parts, is made into a strong infusion with water, q. s.; 1 part lime, reduced to a state of milk with water, is then added; the mixture is next heated to boiling, at once filtered through linen, and treated, whilst still hot, with chloride of ammonium, in fine powder, in slight excess (about 1 oz. to each lb. of opium); the morphine is deposited as the liquid cools, and may be purified by a second solution in lime and precipitation by chloride of ammonium. This process is remarkably simple, and in many points is preferable to any other, either on the small or large scale. (Mohr.)

(5) Pure.—The opium is digested in tepid water, and strongly expressed several times. The solution is evaporated down with powdered carbonate of lime. When about the consistence of a syrup, water is added, and the precipitated meconate of lime is filtered off. The liquid is again concentrated at a gentle heat. When concentrated and quite cold, a solution of chloride of calcium and a little hydrochloric acid are added, and the mixture is left to stand for 15 days. During this time crystals of hydrochlorates of morphine and codeine are deposited. In order to separate these, the crystals are dissolved in water, and treated with dilute ammonia, which precipitates the morphine, leaving the codeine in solution. The morphine is purified by repeated crystallisations in alcohol. When prepared in this way, morphine is often contaminated with a little narcotine, which may be removed by treating with ether, in which morphine is quite insoluble.

Narcotine is prepared from opium by the following methods: (1) From opium exhausted of soluble matter by cold water, by treating it with water acidulated with acetic or hydrochloric acid, filtering, neutralising with ammonia, and dissolving the washed precipitate in boiling alcohol; the narcotine is deposited as the liquid cools, and may be purified by solution in ether. (2) By acting with ether on opium previously exhausted by cold water. (Cooley.)

Nicotine is obtained from tobacco-leaves by the processes enumerated below:—

(1) Infuse tobacco-leaves for 24 hr. in water acidulated with sulphuric acid, strain, evaporate to a syrup, add ⅙ of its volume of a strong solution of potash, and distil in an oil-bath at 288° F. (142° C.), occasionally adding a little water to assist the process and prevent the too great concentration of the solution of potash in the retort; next saturate the distilled product with oxalic acid, evaporate to dryness, digest in boiling absolute alcohol,

evaporate the resulting tincture to a syrup, and decompose the oxalate of nicotine thus obtained by adding potash to it in a close vessel, and agitate the mass with ether, repeating the process with more ether until all the nicotine is dissolved out; lastly, distil the mixed ethereal solution in an oil-bath. At first ether comes over, then water, and lastly nicotine, which, towards the end of the process, assumes a yellowish tint. (Ortigosa.)

(2) This chiefly differs from the preceding by the concluding distillation being conducted in a retort, by the heat of an oil-bath, at the temperature of 284° F. (140° C.), in a current of hydrogen, for 12 hrs.; after which, by raising the heat to 356° F. (180° C.), the nicotine distils over pure, drop by drop. (Schlösing.)

(3) A tin vessel provided with 2 tubulures is filled with tobacco, which is previously damped with sodium carbonate. One of the tubulures admits a glass tube reaching nearly to the bottom of the vessel; the other is provided with a glass tube merely penetrating the cork. The vessel is made air-tight, placed in a boiling-hot steam bath, and a rapid stream of carbonic acid gas is passed through it, entering the vessel by the longer and leaving it by the shorter tube; the latter dips into a mixture of alcohol and dilute sulphuric acid. In this manner a large yield of perfectly colourless nicotine is obtained. In order to obtain the pure alkaloid, caustic baryta is added to the solution, the latter is evaporated to dryness, and the pure nicotine is extracted with ether. (Kirschmann.)

Piperine is obtained from black pepper (*Piper nigrum*) as follows. The alcoholic extract is treated with a weak solution of caustic potash (1 to 100), and the residue, after being washed with cold water, is dissolved in alcohol; the solution is next agitated with a little animal charcoal, and the filtrate is allowed to evaporate spontaneously; the product may be purified by re-solution in alcohol and re-crystallisation. (Cooley.)

Quinine, etc.—Of the alkaloids present in cinchona barks, the four possessing remedial value are, stated in order of merit, quinidine, quinine, cinchonidine, and cinchonine. Their relative and total proportions are each subject to great variations, in fact no two samples of the bark are alike. Until recently, quinine was the only member of the group admitted into use; but experiment has shown that cinchonidine and cinchonine are very little inferior to the former as a febrifuge, and it is probable that they will not be thrown away in future. Quinidine is in too small proportion to deserve special notice. Though it is impracticable to state the percentage of alkaloids, individually or collectively, in each species of bark, the latter are nevertheless distinguished by well-marked characteristics, a knowledge of which is essential for their most economical and suitable employment. Pale or crown bark is rich in crystallisable quinine, and is highly valued by the manufacturers of quinine sulphate in this country. Yellow bark is even more highly esteemed for this purpose. Red bark, on the other hand, while as rich as either of the others in total alkaloids, contains only little quinine, and that difficult of extraction. Moreover, this species is hardier, grows better, and yields about ¼ more bark than *officinalis*, so that as a source of total alkaloids it is more deserving of attention than the other two, though inferior to them if they could be got to grow as luxuriantly. The red bark, too, is the most valuable for the preparation of tonic decoctions, tinctures, etc., largely used in Europe; and in consequence of this fact, its price in Western markets is but little, if at all, inferior to that of the kinds richer in quinine. The barks best adapted for quinine-making fetch the best prices in European markets, and will probably continue to do so. Red bark will doubtless recede in price when production increased, as the demand for that kind is limited in Europe; it is, however, the only kind likely to be used in the east for the local manufacture of a febrifuge, is efficient as, while much cheaper than, sulphate of quinine. Two conditions bearing upon this part of the subject are : (1) That high temperature increases the cinchonidine at the expense of the quinine, so that barks grown at a low elevation (or even at a high elevation, if exposed to sunlight), will be richer in the former and poorer in the latter, while a low mean temperature, within certain limits, favours the production of quinine ; (2) That deprivation of light, without impeding the access of air and sun-heat, materially increases the proportion of total alkaloids.

The manufacture of a cheap febrifuge has engaged the serious attention of the Indian government, resulting in two such products—Broughton's "amorphous quinine," and the febrifuge called "quinetum" by Dr. de Vrij.

The former is prepared in the following way : Strips of the bark are placed in a copper pan with sulphuric acid (1½ per cent. for trunk-bark, 1 per cent. or less for prunings, etc.), and a quantity of water from the fourth extraction (*v. post*) ; the whole is boiled for 1 hr., then subjected to a strong screw press, the liquid being caught in a wooden vat. The bark is reboiled with liquor from a third extraction, with an additional ½ per cent. of acid, for 1 hr., and is again squeezed. A third boiling is given in liquor from a fourth extraction, and, after squeezing the bark is finally boiled with fresh water, sun-dried, and used as fuel. The resulting concentrated decoction is evaporated to ½, and cooled ; it is then decomposed by addition of milk of lime in slight excess, which precipitates the alkaloids, with formation of insoluble lime salts ; after standing for a day, the precipitate is filtered off, squeezed, dried, and powdered. The powder is then placed in the apparatus shown in Fig. 10 ; A B C D is a sheet-iron cone traversed by an upright tube E, terminating above in 4 open arms, and supported below on a flat iron disc C D. A copper vessel F G fits closely to the lower end of the cone. The latter is suspended, and connected through the tube H, with a simple worm tub. The cone is packed with the precipitate up to E, the lid is put on, and alcohol is added slowly from above, till F G is about ½ full of the saturated spirit which is then carefully neutralised by dilute sulphuric acid. The cone is then connected with the condenser through H, and a fire is lighted below. The spirit boiling in F G rises in vapour through E, passes out at the openings, and condenses so as to form a liquid stratum above the precipitate. This is observed by the gauge B I ; uncondensed vapour passes through H, and is caught. A small quantity of spirit, by constant circulation, extracts all the alkaloids without waste. The alkaloid in F G is neutralised with dilute acid every two days. When the precipitate no longer contains any alkaloid, F G is removed, and the alcohol is distilled off ; the alkaloid is washed with water, while the alcohol is recovered with a maximum loss of 6 per cent. The alkaloid is treated suddenly with about 10 times its bulk of cold water, which separates the black resin present ; the addition of a little dilute acidulated solution of sodic sulphide will remove any copper accidentally present. The alkaloid solution being still coloured, a small quan-

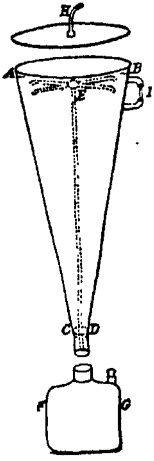


FIG. 10.

tity is precipitated by dilute caustic soda, the colouring matters falling at the same time. The whole is then filtered through cloth; and the alkaloid is precipitated by caustic soda, filtered, pressed, dried, and powdered. Potash may replace soda, if more easily or cheaply procurable. This process was employed to produce 600 lb. of alkaloid in the Nilgiris; but the product was found to cost more than ordinary commercial quinine, assuming the value of dry trunk bark at 2*s.* a lb., and branch-bark at 6*d.* The yield of alkaloid is, however, naturally much greater.

The second method, adopted by Wood, in Sikkim, is much simpler: The dry bark is crushed into small pieces—not powdered—and is put into casks, where it is macerated in the cold with very dilute hydrochloric acid; the liquor is then run off into wooden vessels, and mixed with an excess of strong solution caustic soda; the precipitate formed is collected on calico filters, and well washed with water. The precipitate is then gently dried, and powdered, constituting the crude febrifuge which requires purifying. This is performed by dissolving the product in dilute sulphuric acid, and adding a small quantity of a solution of sulphur in caustic soda. After 24 hrs., the liquor is carefully filtered; the filtrate is mixed with caustic soda, and the resulting precipitate is collected on calico, washed with a little water, dried, and powdered; it is then ready for use.

The operation is conducted in casks, worked in sets of three. Each cask receives 1 *maund* (82 lb.) of dry bark, which will undergo four successive macerations of half a week's duration, the liquor being passed through the three casks in rotation. The liquor used for the 4th (last) maceration is acidulated water; when drawn off, it forms the liquor for the 3rd cask; thence it is conducted to the 2nd cask; and finally to the 1st cask, containing new bark, whence it is run off for precipitation. When starting anew, each cask will contain dry bark, so that the system of rotation is not brought into full operation till after the first fortnight. The liquor for precipitation is run into tubs; the others are drawn into buckets for transference to the respective casks. Acidulated water is made in a vat, by adding 1 gal. hydrochloric acid to 100 gal. water. The weight of acid used in the exhaustion is 6¼ per cent. of the weight of dry bark. The caustic soda solution consists of 1 part of the alkali dissolved in 3 parts of water; it is stored in iron vessels. The quantity required for precipitation of the bark liquor is judged of by the curdy appearance assumed by the precipitate; every 100 lb. of dry bark consumes about 6½ lb. of the alkali.

Filtration of the precipitate is commenced on the following day, when the liquor is transferred to the calico strainers, previously wetted. The first portions that run through are returned, until the passing liquor has a bright ruby colour; it is then allowed to flow away by a drain. When all the liquor has drained off, water is passed through the precipitate, until it ceases to acquire a red tint. The alkaloids on the filter should then exhibit a uniform cream-colour. The precipitate is dried, reduced to fine powder, and stored in suitable bins.

During the drying of the precipitate, a slight reddish-brown colour is developed; this is removed by the following process of purification: 14 gal. of water are mixed with 2 pints of sulphuric acid, and 20 lb. of the dry powder; about ¼ pint of solution of sulphur in caustic soda is stirred in, and the whole is left for 24 hours. It is then filtered through calico into a clean vessel, care being taken to get the liquor perfectly bright; about 6 gal. of water are used to wash the sediment left on the filter; the clear filtrate is thoroughly mixed with soda solution, to precipitate the alkaloids; the precipitate is collected on calico, washed with a small quantity of water, drained dried, and reduced to fine powder.

Wooden vessels are not so suitable for this operation as are those of enamelled iron, or earthenware.

The bark used is exclusively dry *succirubra*, and care is taken to mix the root-, stem-, and branch-barks together, as nearly as possible in the proportions in which they are yielded by the plantations. Green bark would not be available at all seasons; and it has been found that the trifling cost of drying the bark is more than repaid by the better product.

The purified febrifuge is a fine white powder, which, however, acquires a slight buff tint by keeping. It never agglutinates, and is freely soluble in weak acids, such as lemon-juice, etc. The cost price of this febrifuge is estimated at 1*s*. 9*d*. an oz.; it is as efficient as quinine at 9*s*. an oz.

Quinine.—The bark is powdered, and boiled several times with sulphuric, or hydrochloric acid; after each boiling it is carefully expressed, and afterwards the liquors are mixed together. The quinine, cinchonine, and some impurities are precipitated with carbonate of soda, and the precipitate is collected in a cloth, compressed, dried, and digested with alcohol. The solution is next treated with dilute sulphuric acid, in sufficient quantity to exactly saturate the alkaloids, after which the alcohol is removed by boiling. The liquid is now allowed to cool, when the quinine is deposited as sulphate in crystals. The cinchonine, which is more soluble remains in the mother-liquors. The crystals of sulphate of quinine are dissolved in alcohol, and the solution is decolorised by the addition of a little animal black; they are subsequently purified by recrystallisation. If the mother liquors still contain quinine, they are precipitated by carbonate of soda, and the precipitate is re-dissolved in sulphuric acid. The sulphate of quinine is separated by repeated crystallisations. Pure quinine may be prepared from the sulphate by precipitating it with a mineral alkali. (Spons' 'Encyclopædia.')

Salicine is found in the bark and leaves of several species of *Salix* and *Populus*, but most abundantly in the white willow (*S. alba*) and aspen (*P. tremula*). It is prepared as follows:—

(1) Exhaust willow bark by repeated coction with water, concentrate the mixed liquors, and, while boiling, add litharge until the liquid is nearly decolorised; filter, remove the dissolved oxide of lead, first by sulphuric acid, and afterwards by sulphuret of barium; filter, and evaporate, that crystals may form; the crystals must be purified by re-solution and re-crystallisation. (Merck.)

(2) As No. 1, but using a stream of sulphuretted hydrogen to free the solution from lead.

(3) To a strong filtered decoction of willow bark add milk of lime, to throw down the colour; filter, evaporate the liquor to a syrupy consistence, add alcohol (sp. gr. 0·847), to separate the gummy matter, filter, distil off the spirit, evaporate the residue, and set it aside in a cool place to crystallise; the crystals are purified by solution in boiling water, agitation with a little animal charcoal, and recrystallisation.

Strychnine may be obtained from nux vomica (*Strychnos nux vomica*) and from the Ignatius bean (*S. Ignatii*) by the following methods:—

(1) Dissolve hydrochlorate or sulphate of strychnine in distilled water, and throw down the alkaloid with ammonia, carefully avoiding excess; redissolve the precipitate in hot rectified spirit, and collect the crystals which form as the liquid cools.

(2) Nux vomica (in powder), 1 lb., is digested for 24 hrs. in ½ gal. of water acidulated with 2 fl. dr. of sulphuric acid, after which it is boiled for ½ hour, and the decoction decanted; the residue is boiled a second and a third time with a fresh ½ gal. of water acidulated with 1 fl. dr. of the acid, and the undissolved matter is finally submitted to strong expression; the decoctions are next filtered and concentrated to the consistence of a syrup, which is boiled with 3 pints rectified spirit for about 20 minutes, hydrate of

calcium (1 oz., or q. s.) being added in successive portions during the ebullition, until the solution becomes distinctly alkaline; the liquid is then filtered, the spirit distilled off, and the residue dissolved in diluted sulphuric acid, q. s.; ammonia, in slight excess is added to the filtered solution, and the precipitate which falls is collected upon a paper filter, and dried; it is next re-dissolved in a minimum of boiling rectified spirit, and digested with ½ oz. of animal charcoal for 20 minutes; the filtered liquid, as it cools deposits strychnine in crystals.

(3) Nux vomica, 1 lb.; acetate of lead, 180 gr.; solution of ammonia, q. s. Subject the nux vomica for 2 hours to steam in any convenient vessel; chop or slice it; dry it in a water-bath or hot-air chamber, and immediately grind it in a coffee-mill. Digest the powder at a gentle heat for 12 hours with 2 pints of the spirit and 1 pint of the water, strain through linen, express strongly, and repeat the process twice. Distil off the spirit from the mixed fluid, evaporate the watery residue to about 16 oz., and filter when cold. Add now the acetate of lead, previously dissolved in distilled water, so long as it contains any precipitate; filter; wash the precipitate with 10 oz. of cold water, adding the washings to the filtrate; evaporate the clear fluid to 8 oz., and, when it has cooled, add the ammonia in slight excess, stirring thoroughly. Let the mixture stand at the ordinary temperature for 12 hours; collect the precipitate on a filter, wash it once with a few oz. of cold distilled water, dry it in a water-bath or hot-air chamber, and boil it with successive portions of rectified spirit, till the fluid scarcely tastes bitter. Distil off most of the spirit, evaporate the residue to the bulk of about ½ oz., and set it aside to cool. Cautiously pour off the yellowish mother-liquor (which contains the brucine of the seeds) from the white crust of strychnine which adheres to the vessel. Throw the crust on a paper filter, wash it with a mixture of 2 parts of rectified spirit and 1 part of water, till the washings cease to become red on the addition of nitric acid; finally dissolve by boiling it with 1 oz. of rectified spirit, and set it aside to crystallise. More crystals may be obtained by evaporating the mother-liquor.

Veratrine is easily exhausted from the seeds of *Veratrum Sabadilla*, by the following process:—

The crushed seeds are exhausted with a 2 to 3 per cent. solution of oxalic acid for 24 hours, when a clear liquid is afforded, and is neutralised by ammonia. After about ¼ hour, a precipitate is formed in the liquid; this is separated by filtration, and dissolved in pure cold alcohol. The alcoholic tincture, on evaporation, yields vetratine that is sufficiently white and crystalline. It is obtained perfectly so by dissolving in ether, without using any decolorising material. (Alessandri.)

ALLOYS.

General Properties. — Alloys are compounds of two or more metals. Every alloy may be regarded as a new metal since it generally possesses properties different from those of the metals of which it is composed; but as the properties resulting from the combination of two metals rarely represent the mean of those metals, it is impossible to foretell the nature of a new alloy. All true alloys consist of compounds of metals in their definite chemical proportions; it is, however, a matter of some difficulty to obtain them in a separate state, owing to the readiness with which they dissolve in the excess of that metal which may happen to preponderate. There are some few alloys also in which the constituent metals seem to be merely mechanically mixed. Alloys possess the properties which are characteristic of metals, such as metallic lustre, conductivity of heat and electricity, and, in a greater or less degree, malleability, ductility, and tenacity. The specific gravity of an alloy appears to depend upon the amount of cohesion or attraction exerted by the constituent metals for one another and to bear no reference whatever to the high or low specific gravity of those constituents in their free state. Their fusibility does not at all depend upon that of their constituents, but is generally greater; thus the melting-point of tin is 455° F. (235° C.), and that of lead 626° F. (330° C.), whereas a compound of 5 parts of tin and 1 part of lead melts at 381¼° F. (194° C.), and a compound of equal parts of both metals melts at 465¾° F. (241° C.). The ductility of alloys is usually slightly less than that of their most ductile constituent, and their hardness is greater than the mean hardness of both or all the metals. The tenacity of an alloy is often much greater than that of either of the metals alone.

Alloys of gold, silver, and copper are generally superior in strength to any of the more fusible metals, and may be forged either when red-hot or cold. These 3 metals seem to unite in any proportions, and always form an alloy that is malleable when either hot or cold. Pure gold is but little used in the arts: it is too soft. It is generally alloyed with silver and copper, both to harden it and depreciate its value. Alloyed with copper it forms gold of a red tint; with silver, it forms gold of a green tint; and alloyed with both copper and silver, it gives intermediate tints. Pure silver is but little used alone; it is generally alloyed with a small amount of copper, which does not change its colour, and greatly improves its malleability and working qualities. When gold, silver, or copper is alloyed with the more fusible metals—lead, tin, and zinc—the alloy is less malleable and ductile than alloys of gold, silver, and copper. They are "extreme red-short," and when heated to redness they will fly to pieces under the hammer; and alloys of brass, bell-metal, etc., must be treated with caution, and should never be taken out of the mould while red-hot. Alloys of 2 parts copper and 1 zinc are very soft and malleable, and may be drawn by hammering or easily cut with a file, but an alloy of 1 copper and 2 zinc is as hard and brittle as glass, and may be easily pulverised. An alloy of 2 copper and 1 lead makes a soft, malleable metal, but is inferior to an alloy of copper and zinc. In alloys of 1 copper and 1 lead, the lead will ooze out in cooling. In alloys of 1 copper and 2 lead, the lead will not unite, but will sink to the bottom when cooling. Alloys of 6 copper and 1 tin make a very hard alloy, which gets harder and whiter the more tin is added. Alloys of tin and copper should not be too rapidly exposed to the air, for if a large percentage of tin is used it will strike to the surface and ooze out, or make hard spots in the casting. Alloys of zinc and lead cannot be made without the addition of arsenic, unless the lead is in very small quantity. Alloys of zinc and tin are very hard and brittle, and are but little used alone. By the addition of copper to alloys of these 2 metals, the alloy is rendered more malleable and soft. Arsenic makes all alloys hard and brittle, and is very dangerous to use. It is seldom used except to impart fluidity to the very infusible metals. Alloys of lead and tin are very malleable and ductile when cold, but at a temperature of about 200° F. (93⅓° C.), they lose the power of cohesion, and are exceedingly brittle. The alloys of tin and lead partake of the general nature of these 2 metals. They are soft and malleable when cold, even when a small amount of brittle antimony has been added. An alloy of 6 lead and 1 antimony is very soft and malleable, but an alloy of 3 lead and 1 antimony is very hard and brittle; and an alloy of 1 lead and 1 antimony is harder and more brittle than antimony. (E. Kirk.)

Colours. *Colour of Brass.*—It should be remembered that while a brass that is rich in copper is of a deep golden red colour, the redness does not decrease and merge into a yellow, and the yellow become lighter, in a regular way, as the proportion of copper decreases and that of the zinc increases. It is important that this be noted as anyone ignorant of the fact would unfailingly suppose that the richest coloured brass contained the most copper.

Colour.	Zinc. Per cent.	Copper. Per cent.
Rich gold red .	10	90
Gold yellow .	15	85
Greenish yellow	20	80
Yellow brass .	25	75
	30	70
	35	65
Rich yellow .	40	60
Gold yellow .	45	55
	50	50
Gold red . .	55	45
Reddish white .	60	40
Grey . . .	65	35
White . . .	70	30
	80	20

Copper-Zinc Alloys, colour of.

Content of zinc. Per cent.	Colour.
5 . .	red.
10 . .	red-brownish.
15 . .	red-yellow.
20 . .	reddish-yellow.
22 . .	reddish-yellow.
25 . .	pale yellow.
27 . .	yellow.
30 . .	yellow.
35 . .	dark yellow.
38 . .	dark yellow.
41 . .	reddish-yellow.
50 . .	beautiful gold yellow.
60 . .	bismuth-grey.
70 . .	antimony-grey.
80 . .	zinc-grey.
90 . .	zinc-grey.

Density.—Nies and Winkelmann examined the density of metals in a solid and in a liquid state, and found that, contrary to the generally accepted views on the subject, many melted metals expand when they solidify. Tin, slowly and carefully heated to its melting-point, floated on melted tin, and rose to its surface even after it had been submerged. By attaching pieces of copper to the floating tin, it was found that the increase of density by melting over solid tin was 0·7 per cent., a difference which is almost as great as that between tin at the freezing and the boiling points of water. Lead and cadmium did not yield as decisive a result. Zinc, however, behaved like tin, but showed only a contraction of 0·2 per cent. In the case of bismuth, the floating test is very easily carried out, as this metal shows as much as 3 per cent. Copper and iron showed a slight difference, the peculiarity in the case of iron being well known, and having been the subject of elaborate investigations by Wrightson.

The following table of the alloys, whose density is greater or less than the mean of their constituents, is given by several writers:—

Alloys the Density of which is Greater than the mean of their constituents.

Gold and zinc.
Gold and tin.
Gold and bismuth.
Gold and antimony.
Gold and cobalt.
Silver and zinc.
Silver and tin.
Silver and bismuth.
Silver and antimony.
Copper and zinc.
Copper and tin.
Copper and palladium.
Copper and bismuth.
Lead and antimony.
Platinum and molybdenum.
Palladium and bismuth.

Alloys the Density of which is Less than the mean of their constituents.

Gold and silver.
Gold and iron.
Gold and lead.
Gold and copper.
Gold and iridium.
Gold and nickel.
Silver and copper.
Iron and bismuth.
Iron and antimony.
Iron and lead.

Tin and lead.
Tin and palladium.
Tin and antimony.
Nickel and arsenic.
Zinc and antimony.

Fusibility.—Some metals are almost infusible, and, when heated to the highest heat in a crucible, they refuse to melt and become fluid; but any metal can be melted by combination with the more fusible metals. Thus platinum, which is infusible with any ordinary heat, can be fused readily when combined with zinc, tin, or arsenic. This metal, by combination with arsenic, is rendered so fluid that it may be cast into any desired shape, and the arsenic may then be evaporated by a mild heat, leaving the platinum. Nickel, which barely fuses alone, will enter into combination with copper, forming German silver—an alloy that is more fusible than nickel and less fusible than copper. This alloy is rendered the whiter, harder, and less fusible, the more nickel is added. The less fusible metals, when fused in contact with the more fusible metals, seem to dissolve in the fusible metals; rather than melt, the surface of the metal is gradually washed down, until the entire mass is dissolved or liquefied, and reduced to the state of alloy. In forming alloys of brass, in furnaces where heat enough cannot be obtained to fuse the copper separately, the alloy may be formed by heating the copper to the highest heat, and then adding the zinc or tin in the molten state, so as not to reduce the temperature of the copper.

In forming alloys with new metals, it is usual to melt the less fusible metals first and then add the more fusible metals, and mix them by stirring well together; the rod used in stirring them should be heated to redness to prevent lowering the temperature or chilling the metal. In mixing alloys for bells, the alloy should be well stirred with an iron rod well heated, in which case part of the iron is dissolved, combines with the alloy, and gives the bell a better tone; but alloys of brass that are to be turned or finished should never be stirred with an iron rod, for the iron dissolved from the rod will cause hard specks in the alloy, if not thoroughly mixed. In forming fine alloys, the alloy should be stirred with a rod of the least fusible metal contained in the alloy, or with a wooden stick; the wooden stick, in many cases, is better than a metallic rod, for it causes the metal to boil slightly and unite more thoroughly, but it cannot be used in a little crucible with only a small amount of metal. When alloys are made that contain only a very slight quantity of a metal that is difficult to fuse, as in pewter, it is scarcely possible to throw into the melted tin the ½ per cent. of melted copper, with any certainty of the 2 metals being properly combined; and in forming this alloy, it is customary to melt the copper in a crucible, and then add to it 2 or 3 times its weight of melted tin; this dilutes the copper, and makes an alloy called temper or hardening. This alloy is very fusible, is melted in an iron ladle, and is added to molten tin or lead, to give it the desired hardness, and form pewter. (E. Kirk.)

Following are the melting-points of the elements employed in alloys (Bayley):—

Aluminium	654·5° C.
Antimony	629·5° C.
Arsenic	450° C.
Bismuth	268·3° C.
Cadmium	320° C.
Copper	1080·5° C.
Gold	1061·7° C.
Iron	1550°–1600° C.
Lead	330°–335° C.
Magnesium	632·7° C.
Manganese	1800°-1900° C.
Mercury	– 39·4° C.
Nickel	1400°-1450° C.
Phosphorus	44° C.
Platinum	1775° C.
Silicon	1100° 1300° C.
Silver	960·5° C.
Sulphur	114·5° C.
Tellurium	282° C.
Tin	231·68° C.
Zinc	419° C.

Specific Heat.—The specific heat of alloys was found by Regnault to be very nearly the mean of the specific heats of the constituents. The following rule for obtaining the specific heat of alloys gives a very close approximation to the figures obtained by actual experiment: Multiply the specific heat of each constituent into the percentage amount of it contained in the alloy, and divide the sum of the products by 100. Alloys are not, as a rule, such good conductors of heat and electricity as the metals of which they are made.

Fluxes.—The best flux for alloys of copper and tin is rosin. It should be added when the metals are almost melted. Another good flux is sal-ammoniac. In using this flux the copper is usually melted first and the flux added. When it is in the mushy state, after the flux has been put in, the zinc and tin are added. A good flux for old brass is common rosin-soap. It should be added in small lumps, and stirred down into the metal when in the molten state. In forming alloys of different metals, the molten metals should always be kept under a covering of black glass or pulverised charcoal, to prevent oxidation.

Black flux, as it is commonly called, is composed of 7 parts crude tartar, 6 of saltpetre, 2 of common bottle-glass, and by some a small amount of calcined borax is added. These ingredients are first finely pounded and mixed, and then gradually heated in an iron pot or ladle so as to burn them together. Care should be taken not to overheat the mixture, and as soon as it is thoroughly melted and mixed together it should be removed from the fire and allowed to cool. After it has cooled, it is finely pulverised and sifted, and is then ready for use. It has a great affinity for moisture and should be protected against it by being placed in glass bottles and the bottles corked up until wanted for use. This is the most powerful flux that can be made. It is but little employed in forming or fluxing alloys, but principally by assayers in assaying different kinds of metallic ores. In these assays the quantity of black flux used varies according to the quality of the ores, but the amount is generally about equal proportions of ore and flux. The ore is first roasted, and then finely broken up and mixed with the flux, and the whole is then rapidly heated in a crucible. If the flux does not make the slag sufficiently fluid to allow the metal to settle, a small amount of calcined borax is added, which makes the slag more liquid, and permits the metal to pass to the bottom of the crucible. The crucible is then removed from the fire, and the mixture is either poured from it or allowed to cool in it. After it has cooled, the slag is knocked off with a hammer, and a button of metal is obtained. When using this flux, the clay crucible, without either coal or graphite (plumbago), is preferred, for the flux is very hard on a crucible that contains either of these substances. Black flux is used by some foundrymen in melting the fine scrap-sweepings from the floor, and dross and refuse from the crucible. By melting these in a crucible with black flux, they obtain considerable amounts of metal from them that would otherwise be lost. (E. Kirk.)

Melting.—(*a*) This operation may be carried on in an earthenware crucible, when small quantities are being operated upon; but when large masses of metal have to be dealt with, as in the case of statues, etc., a reverberatory furnace must be employed to effect the melting. As a rule, the least fusible metal is placed in the crucible first, unless it be in very small quantity, and will dissolve readily in the other metal, in which case it goes in last; and if, as in the case of zinc, the volatilisation of the metal be extremely rapid, it is introduced only the moment before the fused mass is ready to be poured into the mould or other receptacle. The order in which the metals are melted has a material effect upon the nature of the resulting alloy, for it has been proved by experiment that the latter often possesses different properties when the mixing has taken place in a different order. The fused metals should be kept thoroughly well stirred up until the mixture is complete; otherwise the heaviest metal will sink to the bottom of the mass, and the alloy will not be of uniform composition. This contingency is sometimes avoided by melting the mass a second time. When three metals have to be united together, they should first be melted in pairs, and afterwards together.

(*b*) Guettier gives the following suggestions on the subject of fusing the metals: (1) The melting-pot should be red-hot (a white heat is better), and those metals first placed in it which require the most heat to fuse them. (2) Put the metals in the melting-pot in strict order, following exactly the different fusing points from the highest degree of temperature required down to the lowest, in regular sequence, and being especially careful to refrain from adding the next metal until those already in the pot are completely melted. (3) When the metals fused together in the crucible require very different temperatures to melt them, a layer of charcoal should be placed upon them, or if there is much tin in the alloy, a layer of sand should be used. (4) The molten mass should be vigorously stirred with a stick, and even while pouring it into another vessel the stirring should not be relaxed. (5) Use a little old alloy in making new, if there is any on hand. (6) Make sure that the melting-pots are absolutely clean and free from traces of former operations.

(*c*) Workmen who are unaccustomed to mixing or treating metals while in a liquid state will generally melt such metal upon a blacksmith's forge by applying heat so rapidly that the ladle will become red-hot before the metal within it begins to melt. When it has melted, a dross rises to the surface, and is skimmed off by the workmen and thrown away. The skimming process is kept up as long as the ladle remains on the fire. Now, such a course is wrong, because, by applying heat too suddenly, the metals which fuse at lower degrees of heat, sweat out, and are burned before those which melt at higher temperatures become fluid. The dross, as it is commonly called, which rises to the surface, is in many cases, the antimony, or hardening property of the alloy, and should not be thrown away. The surface of the melted metal should be kept covered with fine charcoal, which will prevent oxidation. A small lump of sal-ammoniac should also be kept upon the surface of the metal. The metal should always be stirred before pouring otherwise the heaviest metals will separate and sink to the bottom of the ladle, and a constantly varying quality of metal will be the result. By melting the metal slowly, and keeping it properly fluxed as described, it will run sharp; each casting will be found uniform throughout, and the metal will be of equal hardness. In observing these simple precautions, much of the dissatisfaction now experienced in using antifriction alloys will disappear.

(*d*) *Manganese Alloys.*—In practice, the copper should be first melted in a crucible in the ordinary manner, and the *spiegel-eisen* or ferro-manganese, either with or without the addition of wrought-iron scrap, should at the same time be melted in a separate smaller high temperature furnace, in a plumbago (graphite) crucible, under powdered charcoal; when it is completely fused, the copper also fused and at a boiling heat, the ferro-manganese should be poured into the copper, and the two well mixed together by stirring with an iron rod previously made red hot; the tin, zinc, or both should then be added in the usual way, and in the requisite proportions according to the kind of alloy it is required to produce. After the tin and zinc are added, the metal should be again well stirred with a red-hot rod, and skimmed; it may then either be poured into ingot moulds for future use, or it can at once be cast into moulds to produce any articles required.

While most experimenters have succeeded in combining manganese and copper by simultaneous reduction from their respective oxides — Heusler Brothers, of Dillenburg, recognised a greater advantage in reducing metallic manganese from pure pyrolusite for itself, and afterward alloying it in any required proportion with other metals. The reduction takes place in large plumbago (graphite) crucibles, with an admixture of carbon and of very basic materials, by which after 6 hours' smelting in a powerful coke fire, "crude manganese" is obtained, this containing 90 to 92 per cent. manganese, 6 to 6·5 carbon, 0·5 to to 1·5 iron, and 0·5 to 1·2 silicon. The crude metal can be refined to contain 94 to 95 per cent. manganese, when it is remelted with a suitable flux, and this metal contains only combined carbon, while in its crude state graphitic carbon also is almost always present. The refined metal is white, with crystalline fracture, and it oxidizes slowly when exposed to damp air; it is, therefore, soon combined with copper, thus forming "manganese copper," with 70 parts copper and 30 manganese. The alloy is cast either in ingots or shot, and becomes a commercial article in this state; its fracture is of steel-grey colour and very close, and it is not difficult to combine it in any proportion with other metals or alloys, such as brass, bronze, gun-metal, bell-metal, yellow-metal, and others. The same combination has been found a very powerful "physic" in refining copper, because the manganese will take up all oxygen which is absorbed by the bath of refined copper in the refining furnace before it is made tough, either by an addition of lead or by an insertion of a pole of green wood.

(e) In the formation of alloys in which one of the metals is more fusible than the other, the less fusible metal should be fused first, and the more fusible metal added either in the molten or solid state. As the fusible metals are added, the temperature of the alloy should be reduced, to prevent oxidation or burning away of the fusible metals; for this reason, it is better to add the more fusible metals in the solid state, as by so doing the temperature of the metal is decreased. Alloys are always more fusible than the less fusible metals of which they are composed, and in some cases are more fusible than the most fusible metal they contain, as is the case of alloys of tin, lead, and bismuth. Some founders, in order to have the metal thoroughly united, first fuse the metals together, cast them into ingots, and remelt them for use. This practice is bad, for in the after-fusion there is always more or less of the more fusible metal burned away; and it is hard to determine the proportions of the alloy, or to have any certainty as to the quality of the castings. In melting ingots or scrap-alloys, they should be fused as rapidly as possible, and at the lowest available temperature, so as to avoid oxidation.

Furnaces.—Furnaces for melting alloys may be built of common brick and lined with fire-brick; but the best are made with a boiler-plate caisson, 20 to 30 in. diam. and 30 to 40 in. high, usually set down in a pit, with the top only 10 or 12 in. above the floor of the foundry. The ash-pit, or opening around the furnace, is covered by a loose wooden grating, that admits of the ashes being removed. The iron caisson is lined with fire-brick, the same as a cupola, the lining being usually 6 in. or more thick. The inside diameter of the furnace should not exceed the outside diameter of the crucible by more than 4 or 5 in., as greater space will require greater expenditure of fuel. These furnaces are liable to burn hollow around where the crucible rests; to avoid waste of fuel, they should be kept straightened up with fire-clay and sand. Sometimes these furnaces are built square inside, but they are inferior to the circular form, and consume more fuel. Three or four such furnaces are commonly arranged in sets, giving a graduated scale of sizes, to suit the needs of larger or smaller castings. When the quantity of metal used is large, a blast is generally employed.

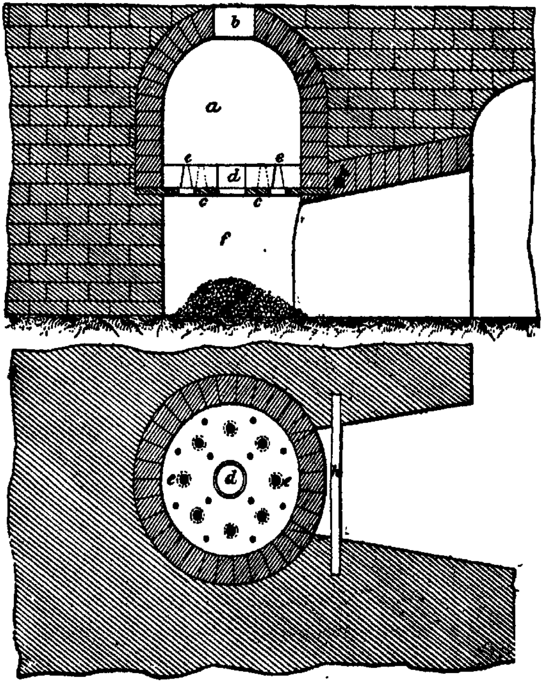


FIG. 11.

The common brass furnace usually depends on a natural draught, and connects by a flue with a chimney stack at the back. Three or four commonly share a single stack, each having a separate flue and damper. When the chimney does not give sufficient draught, the ash-pit may be tightly closed, and a mild blast turned into the pit, to find its way up through the grates. The fuel may be hard coal or coke, broken into lumps about the size of hen's eggs; coke is preferable, as heating more rapidly, and thus lessening the oxidation of metal, but gas-coke from cannel coal is not admissible.

The ordinary cupola furnace is shown in Fig. 11. It consists of a circular chamber *a* built of fire-brick, rising in the form of a dome, in the top of which is a circular opening, carrying a cast-iron ring *b*, through which the pots and fuel are introduced. At the bottom is a bed-plate *c*, which is a circular plate of cast-iron having one large hole *d* in the centre (for the withdrawal of ashes and clinkers), and twelve smaller ones *e* arranged symmetrically around it. Below the bed-plate is the ash-pit *f*, leading to an arched air-passage *g*, which supplies air to the ash-pit. Tapering cast-iron nozzles, 6 in. high, 3 in. diameter at the bottom, 1½ in. at the top, and about ⅜ in. thick, are placed over the twelve small holes *e*. The space between the top of the bed-plate and the top of the nozzles is built up with fire-brick and fire-clay until it forms a surface perfectly level with the top of the small nozzles, leaving the central hole free. These nozzles do the duty of a fire-grate, by admitting the air that supports combustion. The whole construction is enclosed in a solid mass of brickwork, and an iron bar *h* is built in over the air-way in front of the bed-plate, and resting on the walls forming the sides of the air-way, to give support. The dimensions of the furnace shown are 3 ft. 6 in. diameter, and 3 ft. 6 in. in height from furnace-bed to crown of arch.

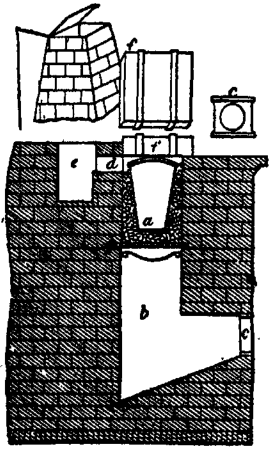
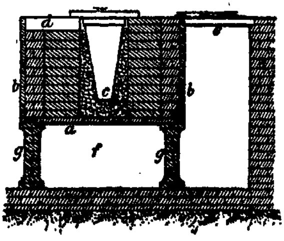


FIG. 12.

The ordinary melting furnace is shown in Fig. 12. The fire-place *a* is lined throughout with fire-brick, as well as the opening *d* into the flue and a portion of the flue *e* itself; *b* is the ash-pit; *c*, register-door of ash-pit, by which the draught is partially regulated; *f*, fire-brick cover for the furnace; *g*, fire-bars. It is built all round with common brick; and as many as six may use the same stack.



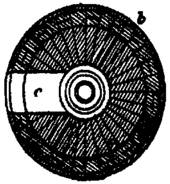


FIG. 13.

Fig. 13 illustrates the circular melting furnace, consisting of an iron plate *a* pierced in the centre by a circular hole, of the size of the interior of the furnace, and crossed by the fire-bars; *b* is a sheet-iron drum riveted together, forming the shell of the furnace, and resting on the bed-plate; it is first lined on the inside with 4½ in. of ordinary brick, and next with 9 in. of fire-brick; *c*, fire-place; *d*, flue leading to stack; *e*, iron grating for admitting air beneath the furnace; *f*, ash-pit; *g*, four small brickwork pillars, about 18 in. high, supporting the bed-plate; *h*, fire-brick cover to furnace. The draught is regulated by a damper in the flue or on the stack. The latter is an iron plate large enough to entirely cover the top of the stack, hinged at one edge, and opened or closed by a lever.

A reverbatory furnace is illustrated in Fig. 14: *a*, fire-place; *b*, ash-pit; *c*, bridge; *d*, melting furnace; *c*, fire-door; *f*, flue leading to stack; *g*, door for feeding in and ladling out metal. The draught is regulated by the fire-door and the damper on the top of the stack.

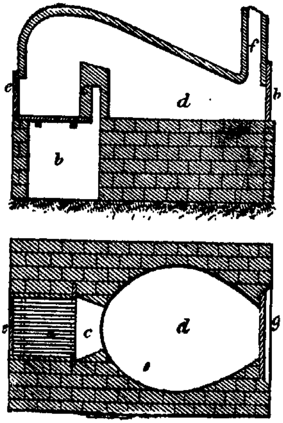


FIG. 14.

Crucibles.—All the metals and alloys, with the exception of iron and the very fusible metals, are melted in crucibles, of which there are several different kinds. The principal ones in use are the Hessian pots, the English brown or clay pots, the Cornish and the Wedgwood crucibles—all extensively used for melting alloys of brass, bell-metal, gun-metal, etc.; but they are very brittle, and seldom stand more than one heat, yet are generally sold cheap, and some founders prefer to use a crucible only once, for crucibles often crack or burn through on the second heat. The best crucibles for all kind of alloys are made of graphite (miscalled plumbago and black lead). These are sold higher than any of the clay crucibles, but they are more refractory, and may be used for three or more successive heats without any danger of cracking or burning through. They are not so open and porous as the clay crucibles, and do not absorb so much of the metal, and for this reason they are to be preferred for melting valuable metals. When about to use a crucible, it should be heated gradually by putting it in the furnace when the fire is started, or by setting it on the top of the tyle or covering of the furnace, with the mouth down; it should be heated in this way until it is almost too hot to hold in the hands. Some founders stand a firebrick on end in the bottom of the furnace to set the crucible on. This prevents the crucible from settling with the fuel, as it is burnt away. This way of supporting the crucible is a good idea, when the furnace has a poor draught, and the metal is melted slowly, and it is necessary to replenish the fuel before the metal can be melted; but in furnaces where the metal is melted quickly, and it is not necessary to replenish the fuel in the middle of the heat, the crucible should be allowed to settle with the fuel, as the heat will then be more concentrated upon it. After the metal has been poured from the crucible into the mould or ingot, the crucible should always be returned to the furnace, and allowed [illegible]cool off with the furnace to prevent it from cracking. In forming alloys of brass, etc., a lid for the crucible is seldom used, but a covering of charcoal or some kind of flux is generally used on the metal. The metal to be melted in the crucible is generally packed in before the crucible is put into the furnace; and when it is desirable to put in more metal after the metal has been fused, it is put in with the tongs, if the metal is in large pieces; but when the metal to be added is in small pieces, it is put into the crucible through a long funnel-shaped pipe. The small end of this pipe is used for putting metals into the crucible, and the large end is used for covering the crucible to prevent the small pieces of fuel from falling into the crucible.

Acid Proof Alloys.—The following have a yellow colour: (*a*) Copper, 53; zinc, 42; manganese, 3¾; aluminium, 1¼. (*b*) Copper, 70 ; lead, 20 ; tin, 3 ; antimony, 7. (*c*) Gun metal—Copper, 75 ; lead, 15 ; tin, 9·9 ; phosphorus, ·1. (*d*) Gun metal—Copper, 88 ; lead, 10 ; tin, 2.

Aich, or Gedge's Metal.—This is an alloy of zinc and copper in nearly the same proportions as in Muntz's metal, but it contains also a little iron, thus :—

Copper	60·0
Zinc	38·2
Iron	1·8

It is very malleable at a red heat, and may be hammered, rolled, drawn into wire, or readily cast. It was formerly employed in Austria for casting cannon, and some Chinese cannon consist of a similar alloy.

Aluminium Alloys.—Some years ago Dr. Ludwig Mach experimented with alloys for the production of metal mirrors. It was considered indispensable that the composition aimed at should be light, hard, tough, and susceptible of polish, and that its gloss should not be easily affected by the air. An equal mixture of magnesium and aluminium proved a very suitable alloy. Following up this discovery, Dr. Mach systematically tried all possible proportions of magnesium and aluminium according to their properties and technical adaptability, giving the most approved one the name of magnalium, on the production of which he obtained patent rights. Before this, various experiments had been made, with a view to the discovery of suitable alloys; but as at that time neither of the two metals could be obtained technically pure, the alloys did not possess the valuable properties which distinguish the new magnalium.

Aluminium, as well as magnesium, is most difficult to work, inasmuch as the former chokes up the file, and is liable to break, while the latter is so tough that neither a file nor the turner's chisel can make any impression. Magnalium, on the other hand, is more suitable than either of its component parts. Alloys containing up to 30 per cent. of magnesium furnish a metal the hardness of which lies about half-way between yellow and red brass, and which may be easily worked with any tool; even the weakest screw-threads can be cut with proper keenness. The chips are like those of yellow brass, the faces of the pieces are smooth and bright, and choking never takes place even with the finest files. Magnalium, moreover, is chemically less assailable than either of its components. Aluminium by itself has a very indifferent exterior, while magnesium by itself is greatly affected by the air, and oxidation will gradually extend far into the interior. Magnalium is silvery white, remains unaffected by exposure to the air, nor can ammonia or acetic or sulphuric acid harm it in any way. It surpasses aluminium in gloss, tractability, firmness, and lightness.

The combinations of aluminium with copper or with zinc can easily be made, but as these two metals are a great deal heavier than aluminium, all the advantages due to the light weight of the latter are lost. While aluminium has a specific weight of 2·7, the alloys referred to range between 3 and 3·5. A notable contrast to this is presented by the specific weight of magnalium, which is less than that of pure aluminium—namely, 2 to 2·5—according to composition. Magnalium produced in Sweden shows a specific gravity of only 2·4 to 2·7

Magnalium is sold in the form of bars, tubes, sheets, and wire. For melting purposes, crucibles of graphite or of iron are used, the inside of the latter having been lined with clay and magnesia. Molten magnalium can be poured into the thinnest vessels of a diameter of down to two millimetres and of the most intricate forms, and will fill them up thoroughly and faultlessly. It becomes soft at 570°, melts at 600°, and becomes fluid at 630° C. On account of its lightness and its silvery white colour it is in a high degree suitable for metallic mountings on photographic apparatus, optical instruments, and similar articles.

Unfortunately, sea-water is inimical to magnalium, especially when the latter comes in contact with other metals.

In cases in which, for technical purposes, great solidity is of paramount importance, as, for instance, in regard to large castings, an alloy of from 3 to 5 per cent. of magnesium is most suitable. An addition of 10 per cent. of magnesium would render magnalium brittle, while 30 per cent. of magnesium would reduce the solidity of the alloy still more. With only 2·4 per cent. of magnesium added, magnalium can be forged at a temperature of 400° C., and will then act in a similar way to copper at red heat. If containing less than 5 per cent. of magnesium, it may be forged in the cold state, and if perchance the hammering has rendered it too hard, it can be made malleable again by heating to a temperature of 500° C., and chilling it thereupon in cold water. ('Journal' of the Franklin Institute.)

(*b*) A writer in the 'Aluminium World' gives the constituents of a hard alloy which has been found very useful for the spacing levers of typewriters. The metal now generally used for this purpose by the various typewriter companies is "aluminium silver" or "silver metal," The proportions are given as follows:—

Copper . . .	57·00
Nickel . . .	20·00
Zinc . . .	20·00
Aluminum . .	3·00
	100·00

This alloy when used on typewriting machines is nickel-plated, for the sake of the first appearance; but so far as corrosion is concerned, nickeling is unnecessary. In regard to its other qualities, they are of a character that recommends the alloy for many purposes. It is stiff and strong and cannot be bent to any extent without breaking, especially if the percentage of aluminum is increased to 3·5 per cent.; it casts free from pinholes and blow-holes. The liquid metal completely fills the mould, giving sharp, clean castings, true to pattern; its cost is not greater than brass; its colour is silver white, and its hardness makes it susceptible of a high polish.

Aluminium Zinc.—The following alloys are strong, and meet all usual requirements:—

	Al.	Zn.	Cu.	Sn.
For wire or sheet	28	5	..	..
,, tubes . .	13	6	·8	·2
With good close grain	20	10	..	..
With good open grain	18	6	..	..

Aluminium Bronze.—(1) This alloy is composed of 90 parts of copper and 10 of aluminium. It is a definite chemical compound, and was discovered by Dr. Percy. It was manufactured for many years at Washington, near Newcastle, by J. Lowthian Bell, who obtained it by melting the copper in a crucible made of graphite or some other highly refractory material; the correct proportion of metallic aluminium was added to the melted copper, the two metals uniting with evolution of intense heat. Aluminium bronze is of a yellow colour, resembling gold; it is extremely hard and tenacious, and possesses great malleability and strength. It is admirably adapted for the working parts of machinery where great durability is required, and has a power of withstanding compression nearly equal to that of the best steel. Aluminium bronze containing 10 per cent. of aluminium possesses the maximum degree of hardness, strength, and tenacity; a larger proportion of aluminium renders the alloy weak and brittle. It has a specific gravity of 7·68; the weight of a cubic inch is 0·276 lb., and the tensile strength 82 tons per sq. in.

(2) 100 parts copper and 10 aluminium, measured by weighing, when combined is a durable alloy, which may be forged and worked in the same manner as copper, and is the same colour as pale gold. 80 parts copper, 19 zinc, and 1 aluminium form a good durable alloy.

Anti-friction Alloys.—A good white metal for lining journal boxes, pillow-blocks, etc., is made of—

Copper	4 parts
Tin	96 ,,
Antimony	8 ,,

In this the tin is in excess, and the alloy is prepared in a roundabout way: 12 parts copper are first melted, and then 36 of tin are added; 24 of antimony are put in, and then 36 of tin, the temperature being lowered as soon as the copper is melted, in order not to oxidise the tin and antimony, the surface of the bath being protected from contact with the air. The alloy thus made is subsequently remelted in the proportion of 50 parts alloy to 100 tin. For small journals, where the friction is not great, both the copper and antimony may be doubled in quantity. An alloy of 1 part copper, 50 tin, and 5 antimony, has a greasy feel, and is good for machines not overworked; but a better metal for lining bearings subjected to rapid, not heavy friction, is made of 85 parts lead, 15 antimony. Vaucher's alloy is composed mainly of zinc and tin, with small quantities of lead and antimony, the last being melted separately. Brasses for locomotive bearings are usually made of—

Copper	64 parts
Tin	7 ,,
Zinc	1 ,,

Babbitt's metal (*see* below) may be described as a tin alloy, 10 parts of that metal being used in conjunction with 1 each of copper and antimony. In recent years, phosphor bronze and manganese bronze have established a good reputation, and latterly cadmium has attracted some attention as an ingredient in alloys for bearings. It fuses below a red heat, and volatilises so readily at the ordinary temperatures necessary for making alloys, that great difficulty has been experienced in using it as an ingredient. It is malleable and ductile, is harder and more tenacious than tin, but soils paper as lead does when it is rubbed over it. Possibly this property has attracted inventors to it, as the fine particles thus removed on slight friction would probably produce a highly smooth surface on a bearing made of an alloy containing cadmium. The proportions preferred are—

Copper	650 parts
Nickel	275 ,,
Cadmium	50 ,,
Zinc and Tin	25 ,,

On different lines of railway, and in various countries, a very large number of alloys have been tried for bearings. Thus, where the freight is light, bearings made of an alloy of lead and antimony have been found to give good results—the life of the journal being prolonged at the expense of the bearing and with an increased consumption of lubricant. Alloys of tin and copper have been tried; but, except in some few proportions, they are too hard; though when the tin preponderates, and there is an addition of antimony, a good bearing is obtained, but at too high a price. Bearings of white metal, and of an alloy of antimony and lead, possess the advantage that they are easily replaced; but unless the supply of lubricant is kept up, they soon wear out, and the latter rapidly fuse, if the journal becomes heated. White metal bearings, with the copper and antimony preponderating, are too hard, too brittle, and break under heavy loads; while, if the tin is in excess, and they are subjected to great pressure, they soon wear out of shape. Dr. Künzel made many experiments on bearings, and concluded that for a bearing to possess all the required qualities it should be heterogeneous in constitution, and that its skeleton, so to speak, should be made of a metal as tenacious as possible, the hardness of which is nearly equal to that of the journal, so as to enable it to resist the shocks to which it is subjected without changing its shape. The insterstices or pores of the skeleton should contain a soft metal. The final result of Dr. Künzel's investigations was the invention of his patented alloy, which consists of phosphor-bronze, with certain quantities of lead and tin added to form the soft alloy for filling the pores. By varying the proportions of the ingredients, and by adding or omitting the proportion of zinc, the hardness of the bearing may be adapted to that of the journal. ('Eng. Mech.')

Antimony.—(*a*) Tin is now so high in price that we find many brass foundries going back to the addition of antimony to certain bronze mixtures to cheapen them. The practice consists in replacing part of the tin in the mixture by antimony. To be sure, spelter is also used; but there are certain cases in which a bronze metal is desired which shall be hard and stiff, and yet have a good colour. The addition of a considerable quantity of spelter is necessary for accomplishing the same thing, and this alters the colour too much.

A favourite mixture used for many classes of work in which stiffness and colour are required is the following: Copper 88 per cent. or 10 lb., zinc 5·50 per cent. or 10 oz., tin 2·75 per cent. or 5 oz., lead 2·25 per cent. or 4 oz., antimony 1·50 per cent. or 3 oz.

While we are not in favour of adding antimony to bronze mixtures, as it produces red-shortness, there are, perhaps, many ornamental castings such as buckles or similar cheap work in which an "Oreide" colour is desired, and the price of which will not afford the use of much tin. We advise those who are not acquainted with these mixtures to try them on a small scale before going ahead, as it may not suit their case. Do not use for any work requiring much strength. ('The Brass World.')

(*b*) Antimony imparts a peculiar beautiful red colour to copper, varying from rose-red in a little copper and much antimony, to crimson or violet when equal parts of these metals are melted together.

Babbitt's Attrition Metal.—Melt separately 4 lb. of copper, 12 lb. best quality tin, 8 lb. regulus of antimony, and 12 lb. more of tin while the composition is in a melted state. Pour the antimony into the tin, then mix with the copper away from the fire in a separate pot.

In melting the composition, it is better to keep a small quantity of powdered charcoal on the surface of the metal. The above composition is called "hardening." For lining-metal, take 1 lb. of hardening and melt it with 2 lb. of tin, which produces the lining-metal for use. Thus the proportions for lining-metal are, 4 lb. of copper, 8 lb. of regulus of antimony, and 96 lb. of tin.

Bearing Brasses should have a special composition, much harder than common brass; the following proportions are found to serve the purpose well: Copper 80 to 82 per cent., tin 10 to 14, zinc 2 to 4. Some use this formula: Copper 84, tin 12, and zinc 4. A cheaper bearing brass is made from copper 51 per cent., tin 8, hard scrap

41 per cent. To some extent the mixtures just described are being displaced in favour of certain proprietary bronzes and by anti-friction white metals; but there is always occasion for the use of this formula on standard work.

Bell-Metal.—An alloy of copper and tin in proportions varying from 3 to 5 parts of copper to 1 of tin. It is of a yellowish-grey colour, hard, brittle, and sonorous, and exhibits a fine-grained fracture. Cooled suddenly from a red heat, it becomes soft, but regains its hardness after being re-heated and cooled very slowly. Small house-bells are usually made of an alloy of 2 parts of copper with 1 of tin; but for larger bells a higher proportion of copper is needed.

The larger the proportion of copper in the alloy, the deeper and graver is the tone of the bells formed from it. The addition of tin, iron, or zinc causes them to give out a sharper tone. Where the quality of the tone is the chief object sought after, care must be taken to employ only commercially pure copper. The presence of lead, even in very small quantities, prejudicially affects the sonorousness of the alloy.

The composition of some varieties of bell-metal is shown below:—

(1) Copper, 39 parts; tin 11. This is the most sonorous of all the alloys of copper and zinc.

(2) Copper, 77 parts; tin, 21; antimony, 2. Paler and inferior to the above. ('Founders' Standard.')

(3) Copper, 4 parts; tin, 1. Very deep-toned and sonorous.

(4) Copper, 8 parts; tin, 1. Used for church and other large bells.

(5) Copper, 17 parts; tin. 8. Best proportions for house-bells, hand-bells, etc.

(6) Copper, 72 parts; tin, 26½; iron, 1½. Used by the Paris houses for the bells of small clocks.

(7) Copper, 6 lb.; nickel, 1 lb.; melted and cooled; add 1 lb. zinc and ½ oz. aluminium; melt and cool; melt again, and add ½ oz. mercury and 6 lb. melted copper. Said not to tarnish nor crack, and to be lighter in weight and give better sound.

Bismuth Bronze.—A metallic alloy, which the inventor calls bismuth bronze, was introduced by Webster, as specially suitable for use in sea-water, for telegraph and music wires, and for domestic articles. The composition varies slightly with the purpose for which the bronze is to be used, but in all cases the proportion of bismuth is very small. For a hard alloy, he takes 1 part bismuth and 16 of tin, and having melted them, mixes them thoroughly as a separate or preliminary alloy. For a hard bismuth bronze he then takes 69 parts copper, 21 spelter, 9 nickel, and 1 of the bismuth tin alloy. The metals are melted in a furnace or crucible, thoroughly mixed, and run into moulds for future use. This bronze is hard, tough, and sonorous; it may be used in the manufacture of screw-propeller blades, shafts, tubes and other appliances employed partially or constantly in sea-water, being specially suited to withstand the destructive action of salt-water. In consequence of its toughness it is well suited for telegraph wires and other purposes where much strain has to be borne. From its sonorous quality, it is well adapted for piano and other music wires. For domestic utensils, and other articles generally exposed to atmospheric influence, the composition is 1 part bismuth, 1 aluminium, and 15 tin, melted together to form the separate or preliminary alloy, which is added in the proportion of 1 per cent. to the above described alloy of copper, spelter, and nickel. The resulting bronze forms a durable, bright, and hard alloy suited for the manufacture of spoons, forks, knives, dish-covers, kettles, tea-pots, jugs, and numerous other utensils. These alloys are said to resist oxidation, to polish well and easily, and to keep their colour well.

Brass.—(*a*) Brass is perhaps the most useful and important alloy known. Its composition varies widely with the uses for which it is intended, but its constituents are copper and zinc, usual-

PROPERTIES OF BRASS.

Atomic Constitution.	Percentage Composition.	Colour of Fracture.	Inverse order of Hardness.	Inverse order of Fusibility.	Nature of the Brass.
Cu	100·00	Tile Red	20	15	Copper.
10Cu + Zn	90·72 + 9·28	Reddish-yellow 1	21	14	
9Cu + Zn	89·80 + 10·20	,, ,, 2	20	13	
8Cu + Zn	88·60 + 11·40	,, ,, 3	19	12	Similor, etc. Several of these are malleable at high temperatures.
7Cu + Zn	87·30 + 12·70	,, ,, 4	18	11	
6Cu + Zn	85·40 + 14·60	Yellowish-red 3	17	10	
5Cu + Zn	83·02 + 16·98	,, ,, 2	15	9	Bath-metal.
4Cu + Zn	79·65 + 20·35	,, ,, 1	16	8	Dutch brass.
3Cu + Zn	74·58 + 25·42	Pale yellow	14	7	Rolled sheet brass.
5Cu + 2Zn	71·43 + 28·57	..	..	..	Ordinary brass.
2Cu + Zn	66·18 + 33·82	Full yellow 1	13	6	British brass.
19Cu + 12Zn	60·00 + 40·00	,, ,,	15	6	Muntz's metal.
Cu + Zn	49·47 + 50·53	,, ,, 2	12	6	German brass.
Cu + 2Zn	32·85 + 67·15	Deep yellow	10	6	,, (watch-makers').
8Cu + 17Zn	31·52 + 68·48	Silver white 1	5	5	Very brittle. Too hard to file or turn.
8Cu + 18Zn	30·30 + 69·70	,, ,, 2	6	5	,,
8Cu + 19Zn	29·17 + 70·83	Silver grey 1	7	5	,,
8Cu + 20Zn	28·12 + 71·88	Ash grey 3	3	5	Brittle. Lustre nearly equal to speculum metal.
8Cu + 21Zn	27·10 + 72·90	Silver grey 2	9	5	,,
8Cu + 22Zn	26·24 + 73·76	,, ,, 1	8	5	Very brittle.
8Cu + 23Zn	25·39 + 74·61	Ash grey 4	1	5	Barely malleable.
Cu + 3Zn	24·50 + 75·50	,, ,, 1	2	4	Brittle.
Cu + 4Zn	19·65 + 80·36	,, ,, 2	4	3	White button metal.
Cu + 5Zn	16·36 + 83·64	Very dark grey	11	2	Brittle.
Zn	100·00	Bluish-grey	23	1	Zinc.

ly in the proportions of nearly two parts of the former to one part of the latter. Brass may also contain small quantities of tin and lead. The qualities which render this alloy so valuable may be briefly enumerated as follows: It is harder than copper, and consequently better able to resist wear and tear. It is very malleable and ductile, and therefore admits of being either rolled into thin sheets, shaped with the hammer, drawn into fine wire, or raised by stamping into objects of various forms. It is readily fusible, and therefore easily cast at a lower temperature than copper. It resists the influences of the atmosphere better than copper, although, if unprotected by lacquer or varnish, it rapidly tarnishes and blackens on exposure to the air. Finally, brass has a fine yellow colour, and is capable of receiving a beautiful polish.

The malleability of brass varies with its composition and with its temperature; it is also affected, to a sensible degree, by the presence, even in minute quantities, of certain other metals. Some varieties of brass are malleable only when cold, others only when hot, and others, again, are never malleable. At a temperature just below its fusing-point, brass, like copper, is brittle, and may be powdered in a mortar. Alloys of copper and zinc present a great variety of colour, ranging between the reddish hue of the former and the bluish-white of the latter; the transition is gradual, and passes through all the intermediate stages of yellow. The table given on p. 55 represents the intensity of colour, hardness, and fusibility possessed by these different alloys.

Brass which is required for rolling into sheets should contain no antimony, as this metal renders the alloy very brittle, and extremely liable to crack. That which has to be turned contains invariably a small proportion of lead, usually about 2 per cent.; this addition is made when the crucible containing the fused metals is taken out of the furnace. The following is an analysis of a brass which is well adapted for this purpose: Copper, 65·8; zinc, 31·8; lead, 2·15; tin, 0·25. The presence of tin was believed to be accidental. Brass required for engraving upon should always contain a little tin, in order to render it sufficiently firm. Brass laminates well in the rolling mill cold, as long as it is kept sufficiently soft; but as by lamination the metal hardens and becomes brittle, it is necessary to restore its tenacity by annealing in an oven or reverberatory furnace. The same process of annealing is necessary in the manufacture of brass wire, which is obtained by drawing it through holes in steel plates, polished carefully and adjusted in series, graduated in size, so as not to diminish too rapidly, and thus render it necessary to employ so much power for drawing as would cause the breaking of the wire. Brass is not usually so prepared as to admit of its being hammered out, as is done in the manufacture of copper utensils; but a brass-foil or Dutch metal, of the colour and approaching the thinness of gold-leaf, is manufactured by beating out thin sheets of brass with hammers worked by water-power, making 300 or 400 strokes per minute.

The copper is first placed in the crucible, and the zinc is added to it bit by bit with much caution, as soon as the former metal is in a state of incipient fusion. The ingots of copper should be heated to redness before being put into the crucible. When the mixture is well fused together, the cinders are removed, and it is poured, if required for casting, into sand-moulds; if, on the contrary, it is to be used for rolling, it is cooled in close iron ingot-moulds, previously heated, oiled, and dusted lightly over in the interior with powdered charcoal. A loss of zinc invariably occurs by volatilisation, which is always taken into consideration when weighing out the metal.

(*b*) The following formulæ show the composition of different varieties of brass:—

For *button brass*, an alloy of 8 parts of copper and 5 of zinc is commonly used. An alloy paler in colour, and used for the common buttons, consists of 25 of copper, 20 of zinc, 3 of lead, and 2 of tin.

For *fine brass*, an alloy of 2 parts of copper with 1 of zinc is the correct proportion; the metals are melted separately, poured suddenly together, and united by vigorous stirring. By raising the proportion of copper to 7 parts of copper and 3 of zinc, a bright-yellow and malleable alloy is obtained; 4 of copper and 1 of zinc yields a metal of darker colour than the last.

Brass for *fine castings* is an alloy of 62 parts of copper, 35 of zinc, 2 of lead, and 1 of tin; this is rather pale and brittle. An alloy used for the same purpose, and of a deep, rich colour, consists of 90 copper, 7 zinc, 2 tin, 1 lead.

For *gilding*, good proportions are: 64 parts copper, 32 zinc, 3 lead, 1 tin.

For *malleable brass*, good proportions are: 33 parts copper, 25 zinc, or, 3 copper and 2 zinc. These are malleable when hot.

For *soldering*, an alloy of 12 parts fine brass, 6 zinc, 1 tin, melted together, is most commonly employed.

For *turning*, the proportions are: 98 parts fine brass, 2 lead, both melted together; or, 65 copper, 33 zinc, 2 lead.

For *wire*, an alloy of 72 parts copper, 28 zinc, is commonly used; this alloy must be afterwards hardened by tempering.

(*c*) The best plan of making brass is to melt the copper in a black-lead crucible first, *dry* the zinc as much as possible, and immerse the whole of the zinc into the copper when the latter is not hotter than barely to continue fluid. Drop a piece of borax the size of a walnut into the pot. When the surface of the hot metal is kept covered by fine charcoal, or by borax, it is prevented from burning, and the smallest loss of zinc is sustained.

The melting together of tin and copper is less difficult than that of zinc and copper, because tin is not so liable to evaporate as zinc, and little metal is lost. The appearance of the alloy may be improved by covering the melted metal with about 1 per cent. of dried potash; or, better still, a mixture of potash and soda. This flux has a remarkable influence on the colour, and particularly on the tenacity of the alloy. The former becomes more red, and the latter stronger. The scum forming on the surface by this addition ought to be removed before the metal is cast. Tin and copper are liable to separation in cooling: this can be prevented, at least partly, by turning the mould containing the fluid metal, and keeping it in motion until it is chilled.

Ordinary brass for castings: 20 copper, 2½ tin, 1¼ zinc.

Hard brass for castings: 25 copper, 4½ tin, 2 zinc.

Red brass for fine castings: 24 copper, 5 zinc, 1 bismuth; add the bismuth last before pouring off.

Red brass for turning: (*a*) 24 copper, 5 zinc, ½ lead; add the lead last before pouring off. (*b*) 32 copper, 10 zinc, 1 lead. (*c*) 160 lb. copper, 50 lb. zinc, 10 lb. lead, 44 oz. antimony.

Rolled brass: 32 copper, 10 zinc, 1½ tin.

Yellow brass: (*a*) 70 copper, 30 zinc. (*b*) 20 lb. copper, 10 lb. zinc, 1 to 5 oz. lead added just before pouring.

Britannia Metal.—

Good: 150 tin, 10 antimony, 3 copper.

Second: 140 tin, 9 antimony, 3 copper.

Casting: (*a*) 210 tin, 12 antimony, 4 copper. (*b*) 100 tin, 5 antimony, 5 hardening. (See below.)

Handles: 140 tin, 5 antimony, 2 copper.

Lamps: 300 tin, 15 antimony, 4 copper.

Registers: 100 tin, 8 antimony, 8 hardening.

Spinning: 100 tin, 4 antimony, 4 hardening.

Spoons: 100 tin, 10 antimony, 5 hardening.

Spouts : 140 tin, 6 antimony, 3 copper.

Hardening : 2 copper, 1 tin.

Bronze.—This alloy has been known and employed since very remote ages. It was used exclusively by the ancients for making swords and other sharp instruments, for coinage, statues, and many other useful and ornamental purposes. It is composed of copper and tin, sometimes with the addition of a little zinc and lead. Great variations are made in the proportions of the two chief constituents, according to the nature of the application for which it is destined. For statuary, the proportions used by the Brothers Keller, the most noted bronze-founders of modern times, were copper, 91·40 ; zinc, 5·53 ; tin, 1·70 ; and lead, 1·37. The bronze coinage of this country contains 95 parts copper, 4 of tin, and 1 of zinc. The addition of a little zinc to the alloy is an advantage, but too much diminishes its tenacity ; lead is objectionable, owing to its tendency to sink after casting, thus destroying the homogeneity of the alloy. The metals should be melted rapidly to prevent loss of metal by oxidation, and the melted mass should be covered with a layer of charcoal, and kept constantly stirred. The operation is generally carried on in refractory crucibles, heated in a reverberatory furnace of suitable form. The cooling in the moulds must be as rapid as possible, in order to prevent the separation of the metals.

The composition of different kinds of bronze is shown below :—

For *edge-tools* : 100 parts copper, 14 tin ; when properly tempered, this alloy is capable of taking nearly as fine an edge as steel.

For *gilding* : (1) copper, 82 parts ; zinc, 18 ; tin, 3 ; lead, 1½ ; (2) copper, 83 ; zinc, 17 ; tin, 2 ; lead, 1 ; (3) copper, 70 ; zinc, 25 ; tin, 2 ; lead, 3. Nos. 2 and 3 represent extremes.

For *medals* : (1) copper, 89 parts ; tin, 8 ; zinc, 8 ; this alloy takes a sharp impression by stamping ; (2) (Chaudet) copper, 95 parts ; tin, 4 or 5.

For *mortars* : copper, 93 parts ; lead, 5 ; tin, 2.

Ornaments.—(*a*) Copper, 82 parts ; tin, 3 parts ; zinc, 18 parts ; and lead, 2 parts.

(*b*) Copper, 83 parts ; zinc, 17 parts ; tin, 1 part ; lead, ½ part.

For *statuary* : (1) copper, 88 parts ; tin, 9 ; zinc, 2 ; lead, 1 ; (2) copper, 82½ ; zinc, 10½ ; tin, 5 ; lead, 2 ; nearly the proportions of the celebrated statue of Louis XV. ; (3) copper, 90 ; tin, 9 ; lead, 1 ; (4) copper, 91 ; tin, 9 ; (5) copper, 91·4 ; zinc, 5·6 ; tin, 1·6 ; lead, 1·4 ; (6) copper, 89·35 ; tin, 10·05 ; zinc, 0·5 ; lead, 0·1.

Bullet Metal.—98 lead to 2 arsenic. For round shot the fused metal is dropped from a high elevation in a shot tower into a basin of water ; or thrown down a stack of limited height, in which a strong draught of air is produced by a blast machine.

Chinese Silver.—65·2 parts copper, 19·5 zinc, 13 nickel, 2·5 silver, and 12 cobalt of iron.

Cock Metal.—Copper, 20 lb. ; lead, 8 lb. ; litharge, 1 oz. ; antimony, 3 oz.

Cymbals, Gongs, and Tamtams.—(*a*) 100 parts of copper with about 25 of tin. To give this compound the sonorous property in the highest degree, the piece should be ignited after it is cast, and then plunged immediately into cold water.

(*b*) 80 parts of copper and 20 of tin, hammered out with frequent annealing.

(*c*) An alloy of 78 of copper and 22 of tin answers better, and can be rolled out.

Fusible Alloys.—Several alloys having very low melting-points are used for purposes where great softness is required. They are chiefly as follows : (1) 8 parts bismuth, 5 lead, 3 tin, melted together ; melting-point, 202° F. (94·5° C.). (2) 2 parts bismuth, 5 lead, 3 tin ; melts in boiling water. (3) 5 parts bismuth, 3 lead, 2 tin ; melts at 197° F. (92° C.). (4)

15 parts bismuth, 8 lead, 4 tin, 3 cadmium ; known as "Wood's patent" ; has a brilliant metallic lustre, does not tarnish readily, and melts between 150° and 160° F. (65½° to 71° C.). (5) 5 volumes each of bismuth, lead, and tin, with 4 of cadmium, form an alloy which is quite liquid at 150° F. (65½° C.). (6) 4 volumes each of bismuth, lead, and tin, with 3 of cadmium, fuses at 153½ ° F. (67½° C.). (7) 2 volumes each of bismuth, lead, and tin, with 1 of cadmium, or 1 volume of each of the four metals, fuses at 155½° F. (68½° C.). (8) 1 part tin, 1 lead, 2 bismuth ; melts at 200° F. (93·5° C.). (9) 15 parts bismuth, 8 lead, 4 tin, 2 cadmium ; melts below 140° F. (60° C.). *N.B.*—All the alloys containing cadmium are liable to undergo rapid oxidation in contact with water.

"Fusible Plug" Alloys.—Kraft's alloy : melting point, 219° F. (104° C.) ; contains 5 bismuth, 2 lead, 1 tin.

Homberg's alloy : melting point, 251½° F. (122° C.) ; contains 3 bismuth, 3 lead, 3 tin.

Rose's alloy : melting point, 199° F. (93° C.) ; contains 2 bismuth, 2 lead, and 2 tin.

German Silver.—This alloy is much used as a substitute for silver ; it is composed of copper, zinc, and nickel. The proportions of the three metals are various. When intended as a substitute for silver, they are 50 parts copper, 25 zinc, and 25 nickel ; castings, such as candlesticks, etc., are made of an alloy containing 60 parts of copper, and 20 of each of the other two constituents. German silver is harder than silver, and susceptible of a high polish. It is of a greyish-white colour ; fuses at a bright-red heat, the zinc being volatilised in the open air. The three metals, in a state of division and intimately mixed, may be melted together in a crucible, having copper at the top and bottom. The whole is covered with a coating of fine charcoal, and strongly heated in an air furnace with a strong draught. Or the copper and nickel may be first melted in the crucible, fragments of hot zinc being afterwards added. To aid the fusion of the nickel, the mixture should be well stirred. Lead is sometimes added, also iron, for the purpose of whitening the alloy.

Actual analyses of various kinds of German silver (including Argentan, Maillechort and Packfong) show the following proportions :—

(*a*) Copper, 50 parts ; nickel, 20 ; zinc, 30 ; very malleable, and takes a high polish.

(*b*) Copper, 50 parts ; nickel, 26 ; zinc, 24 ; good imitation of silver.

(*c*) Copper, 41 parts ; nickel, 18 ; zinc, 41 ; rather brittle.

(*d*) Copper, 50 parts ; nickel, 25 ; zinc, 25 ; good imitation of silver ; white and malleable.

(*e*) Copper, 60 parts ; nickel, 25 ; zinc, 20 ; for rolling and wire ; very tough and malleable.

(*f*) Copper, 40½ parts ; nickel, 31½ ; iron, 2½ ; zinc, 25½ ; made from Hillburghausen ore ; equal to best Chinese sample.

(*g*) Equal parts of copper and nickel ; recommended by Pélouze as being superior to any alloys containing zinc.

(*h*) Copper, 55 parts ; nickel, 24 ; zinc, 16 ; tin, 3 ; iron, 2 ; white metal spoon, sold as German plate.

(*i*) 10 parts copper shavings and 4 parts arsenic in alternate layers, covered with salt, make a white alloy almost resembling silver.

(*k*) Copper, 50 lb. ; zinc, 25 lb. ; nickel, 25 lb.

(*l*) Copper, 50 lb. ; zinc, 20 lb. ; nickel (best pulverised), 10 lb.

(*m*) Copper, 60 lb. ; zinc, 20 lb. ; nickel, 25 lb. Used for spoons, forks, and table ware.

(*n*) Frick's. 53·39 parts copper, 17·4 nickel, 13 zinc.

(*o*) Copper, 60 lb. ; zinc, 20 lb. ; nickel, 20 lb. ; lead, 3 lb. ; iron (that of tin plate being best), 2 lb.

(*p*) In melting the alloy for German silver, it is difficult to combine a definite proportion of zinc with the compound of nickel and copper previously prepared. In fusing the three metals together there is always a loss of zinc by volatilisation, which may be lessened by placing it beneath the copper in the crucible. The best method is to mix the copper and nickel, both in grains first, place them, thus mixed, in the crucible, when melted add the zinc and a piece of borax the size of a walnut. The zinc will gradually dissolve in the fluid copper, and the heat may be raised as their fluidity increases. In this instance, as in all others of forming alloys, it is profitable to mix the oxides of the various metals together, and reduce them under the protection of a suitable flux. The metal nickel can be produced only from pure oxide of nickel; and, as purity of the alloy is essential to good quality, the common commercial zinc is *not* sufficiently pure for forming argentan. Copper cannot well be used in the form of oxide, but grain copper or wire-scraps will serve equally as well.

Gold, Artificial.—(*a*) Pure copper, 100 parts; zinc or preferably tin, 17 parts; magnesia, 6 parts; sal-ammoniac, 3·6 parts; quicklime, 1·8 part; tartar, 9 parts. The copper is first melted; the magnesia, sal-ammoniac, lime, and tartar are then added, separately and by degrees, in the form of powder; the whole is now briskly stirred for about half an hour, so as to mix thoroughly, and then the zinc is added in small grains by throwing it on the surface and stirring till it is entirely fused; the crucible is then covered, and the fusion is maintained for about 35 minutes. The surface is then skimmed and the alloy is ready for casting. It has a fine grain, is malleable, and takes a splendid polish. Does not corrode readily, and for many purposes is an excellent substitute for gold. When tarnished, its brilliancy can be restored by a little acidulated water.

(*b*) Copper, 16 parts; platinum, 7 parts; zinc, 1 part; fused together. This alloy resembles gold of 16 carats fine, or ⅔, and will resist the action of nitric acid, unless very concentrated and boiling.

(*c*) Platinum, 16 parts; copper, 7 parts; zinc, 1 part; put in a crucible, cover with charcoal powder, and melt into a mass.

Gun-Metal.—(*a*) This is also an alloy of copper and tin, in the proportions of 8 or 9 parts of the former to 1 of the latter. It is a very tenacious metal, easily forged, and possesses a considerable amount of resistance; it is the metal of which large guns were formerly cast, whence the name. In order to make a perfectly uniform alloy, the melted metals should be cooled in the moulds as rapidly as possible. Gun-metal of the above composition has a specific gravity of 8·462; the weight of a cub. in. is 0·304 lb., and its tensile strength 15·2 tons to the sq. in.

The composition employed by the Kellers is—100 of copper, 9 of tin, and 6 of zinc. Fesquet states the proportions adopted by the chief European armouries as follows:—

	Copper.	Tin.
England . . .	100	12·5
,, . . .	90	10
,, . . .	88–92	12–8
Austria, Bavaria, Prussia, Russia, Saxony.	100	10
Spain	100	11

(*b*) Brass, 112 lb.; zinc, 14 lb.; tin, 7 lb.

Inoxidisable Alloys.—A new alloy, which resembles silver, and is very ductile and malleable, is composed of 65 parts iron, 23 of nickel, 4 of tungsten, 5 of aluminium, and 5 of copper. The iron and the tungsten are melted together and then granulated, and the water into which the mixture is poured for this purpose must contain 1 lb. of slaked lime, and the same quantity of potash, to every gallon. The product formed by the fusion of the nickel, the copper, and the aluminium is also granulated in water containing the same proportion of lime and potash; and during the melting, the metals in the 2 crucibles must be kept covered with a flux made of 2 parts borax and 2 of saltpetre. A piece of soda or potash weighing about $\frac{1}{2500}$ of the whole mass, is put into the crucible containing the copper, nickel, and aluminium, in order to prevent the oxidation of the last-named metal; and to prevent the same action taking place with the copper a small piece of charcoal is added. It is advisable before the operation of granulation, to well stir the contents of the 2 crucibles. The granulated metals are dried, melted in the proportion given above, well shaken, and then run into bars. The metal is called "sideraphthite." Another formula for its preparation is: 66 parts iron, 23 nickel, 5 copper, and 4 tungsten.

Lemarquand's inoxidisable alloy contains 750 copper, 140 nickel, 20 black oxide of cobalt, 18 rod tin, 72 pure zinc.

Marlie's consists of 10 parts of iron, 35 nickel, 25 brass, 20 tin, 10 zinc, plunged while hot into a mixture of 30 parts sulphuric acid, 10 nitric acid, 5 hydrochloric acid, 25 water.

Impressions.—Lead, 3 lb.; tin, 2 lb.; bismuth, 5 lb.

Iridio-Platinum.—Platinum is capable of being united to most other metals, the alloys being as a rule more fusible than platinum itself. It occurs in nature in combination with a rare metal called *iridium*, with which it is often alloyed; the resulting metal is called *iridio-platinum*, and though still malleable is harder than platinum, and unattacked by aqua regia, it is also much less readily fusible than platinum itself. Silver is hardened, but rendered brittle, by being alloyed with very small quantities of platinum.

Iron Alloys.—All substances added to iron, according to Kirk, make it more fusible. Lead added in small quantity makes iron soft and tough, but in excess renders it "extreme cold-short." Copper induces "extreme red-short"-ness, and over 1 per cent. will make the iron "cold-short," but small quantities increase the strength of iron when cold. Arsenic imparts a silvery whiteness, but renders the iron brittle. Tin also whitens iron, and in about equal proportions makes it as hard as steel, but the alloy cannot be forged. The chromium alloy of iron is as hard as bort, but difficult to make. Tungsten steel, containing 6 to 8 per cent. of the former metal, is excessively hard and tough, but requires much care in manufacture. Silver renders iron hard, brittle, and very liable to corrosion. Gold produces toughness, and a yellow colour; this alloy is used for small iron castings. Carbon increases the fusibility; 1 to 2 per cent. makes hard cast iron, 5 to 6 foundry iron, less than 1 per cent. renders the iron very hard and brittle, and over 6 per cent. causes extreme brittleness. Sulphur causes iron to be both hard and brittle, when either hot or cold, and it makes molten iron "short-lived"; fuel containing sulphur should not be used for melting iron in contact with the fuel. Phosphorus is very injurious to iron; ½ per cent. will cause iron to be very hard and brittle when cold, but it imparts a brilliant and white colour to iron more perfectly than any other metal. Silicon makes iron brittle and hard; it has a similar effect to phosphorus, but it is not so injurious. All cast iron contains more or less carbon, sulphur, phosphorus, and silicon, and, as these substances predominate, they form hard or soft, strong or brittle irons; and as all anthracite coal and coke contain more or less of these substances, anthracite or coke iron is less pure and more variable than charcoal iron, and, on account of the uncertain amount of these impurities contained in cast iron, it is very difficult to make an alloy of iron and other metals with any certainty as to the result: for this reason, alloyed iron is very little used.

Faraday and Stodart made a nickel-iron alloy by adding ·3 per cent. of nickel to a good iron, and exposing in a crucible to a high temperature during several hours. The metals were melted; and on examining the button, the nickel was found combined with the iron. The alloy appeared to be as malleable and easily worked as pure iron; its colour was tolerably white when polished; the specific gravity was 7·804. On melting horse-shoe nails with 10 per cent. of nickel, the metals were found perfectly combined but the alloy was less malleable, and easily broken under the hammer. Polished it had a yellow tinge; its specific gravity was 7·849. This alloy was affected very slightly by humidity, compared to what would have happened had the iron been pure. According to Berthier, the alloy, consisting of—

Iron . .	0·917	12 at.
Nickel . .	0·083	1 ,,

which is obtained by reducing a mixture of the 2 oxides in a crucible lined with charcoal, is semi-ductile, very tenacious, and has a granular fracture, slightly lamellar.

Iron in all states (malleable, cast, and sheet) unites with gold in any proportion by fusion: 3 parts iron and 1 of gold enter into fusion together at a temperature inferior to that necessary for melting iron; equal parts of the 2 metals give, by fusion, a greyish mass, somewhat brittle, and attracted by the magnet; with 6 parts gold and 1 of iron, a white alloy is obtained, which is attracted by the magnet, ductile while cold, and at a moderate heat becomes yellow, red, and blue; 9 of iron and 1 of gold form an alloy which resists the file, unless previously subjected to a red heat; with 28 of iron and 8 of gold, the alloy is as white as pure silver, and more yielding under the fire and hammer than ductile iron. According to Hatchett, the alloy formed with 11 parts gold and 1 of iron is very ductile, of great resisting power, and harder than gold. Without any preparation, it can readily be cut into blocks, laminated, or struck into medals. This alloy is of a pale yellowish-grey colour, approaching dirty white. Its specific gravity is 16·885.

Iron combines with tungsten by heating to the proper point, in a crucible, a mixture of 100 parts iron, 50 of the yellow oxide of tungsten, and a sufficient quantity of charcoal. After fusion and cooling, there is found a perfect button of a brownish-white colour, hard, rough to the touch, and of an even fracture. Hassenfratz obtained an alloy of the 2 metals, which forged easily enough, although slightly brittle; it was ductile, cracked in the tempering, and assumed in forging a partially fibrous partially granular texture. Karsten concludes from these experiments, that tungsten (in this respect resembling titanium) only increases the hardness of iron. The alloy, composed of—

Iron . . .	0·63	6 at.
Tungsten . .	0·37	1 ,,

is, according to Berthier, of a whiter grey than iron, shining, hard more brittle than ordinary cast-iron, and of lamellar structure.

The union of iron and antimony is readily effected by fusion, and it would seem that it may take place in all proportions. These metals have a great affinity for each other. Their alloys are much more fusible than iron, and are white, hard, and very brittle. Their specific gravity is less than the mean of that of the 2 metals. According to Thompson, this alloy may be obtained by fusing in a crucible 2 parts antimony sulphide and 1 of iron. This alloy was formerly called *regulus martialis*, used in medicine for the preparation called "Mars' saffron," or "aperient antimony." The magnetic character of iron is much more diminished by its alloy with antimony than by almost any other metal. The iron is also rendered harder, much more fusible, and brittle, like cast-iron. Antimony, in uniting with iron, becomes harder and less fusible. Karsten added to cast-iron, after liquefaction, 1 per cent. of antimony; notwithstanding its volatility, this metal exercised on iron a worse influence than even tin. The iron became very brittle at all temperatures.

Karsten found that by the addition of 15 per cent. of fine silver to iron during the refinery operation, the quality of the iron was sensibly deteriorated: it did not forge well, became scaly, the bars presented cracks at the edges, and otherwise resembled hot-short iron. Analyses showed that it contained 0·034 per cent. of silver. It would appear, therefore, that silver has the same influence as sulphur upon iron, although in a less marked degree.

Iron and arsenic may be combined by fusion in any proportion. When the amount of arsenic is large, the magnetic character of the iron disappears. The alloy of these metals is more or less white, hard, brittle, and fusible, according to the amount of arsenic. It is crystallisable, its fracture more dense, and the texture closer than that of iron ; according to Achard, similar to that of steel. Cadet asserts that this alloy will receive a brilliant polish, and that articles of jewellery are made from it.

Iron has a great affinity for chromium, and the 2 metals form alloys in all proportions. These compounds are generally hard, brittle, crystalline, of a greyer white than iron, of considerable lustre, less fusible, much less magnetic, and very much less soluble in acids than iron ; the characters are the more prominent in proportion to the amount of chromium.

The alloy, composed of—

Iron . .	696·00	0·83	5 at.
Chromium	351·82	0·17	1 ,,

is nearly of a silver white, with a fibrous texture, not easily yielding to the file, and very brittle. Merimée, with the aid of a cutler, tried 2 different alloys prepared by Berthier, the one containing 0·010 chromium, the other 0·015. Both forged extremely well ; the former indeed appeared more easy to forge than pure cast-steel. Blades were made out of them for a sword and razor, and both were found to be of excellent quality, their edges being hard and lasting. But the most remarkable characteristic was the readiness with which this alloy received a beautiful damascening when rubbed with sulphuric acid. This damascening presented an agreeable variety of veins of a very brilliant silver-white, much resembling that which is obtained from steel alloyed with silver. The white parts, according to Berthier, are probably pure chromium, upon which the strongest acids have scarcely any action. In the Chrome Steel Works of Brooklyn, the chrome-iron ore is ground fine, and reduced with powdered charcoal in crucibles. The resulting mass is carefully weighed, ground, mixed with Swedish or wrought-iron and melted in crucibles in charges of 75 lb. In 24 hours, the contents of 6 crucibles can be melted. The hardness of the resulting steel depends on the amount of chromium contained, which may vary from 0·25 to 2 per cent.

Copper, according to Karsten, may combine with any proportion of iron, augmenting its tenacity and hardness. Rinmann, for this reason, thinks that it would make, with raw cast-iron, an excellent alloy for anchors, mortars, anvils, cylinders, etc. 200 parts grey cast-iron, and 10 of red copper in thin shavings, immersed in linseed-oil, and submitted, with the addition of charcoal, to a very hot forge fire during 25 minutes, yield, according to Rinmann, a homogeneous metallic button, composed of 104 iron, 6 copper. This alloy is very hard ; its density is 7·467 His experiments show that 200 parts copper and 10 of grey cast-iron, treated in the same way, yield a homogeneous button very ductile when cold. With 16 of copper and 1 of raw cast-iron, he obtained a ductile alloy that was magnetic, and resisted the file better than pure copper ; the surface and fracture were of a fine red colour. Finally, 8 of copper, and 1 to 4 of iron, give alloys which are harder than the preceding, but not perceptibly more brittle nor less coloured than copper. According to Lavoisier, iron containing copper possesses greater tenacity than any other, and becomes brittle only in the stages between a brown-red and deep-red heat: above or below this temperature it can readily be forged. Berthier affirms, in like manner, that iron containing copper possesses great tenacity when cold, but that it is brittle when hot, and can be forged only when above a reddish-white heat or below a cherry-red heat. It is probable, he says, that a large proportion of copper, 1 per cent. for example, would give the cast-iron additional tenacity, and make it better fitted to be employed in castings.

According to Dumas, tin enters into alloy with iron in all proportions. Heated to a high temperature, they melt; but at a moderate heat, separation takes place—a species of liquation. At first a quantity of pure tin, more or less considerable, is melted; then tin alloyed with iron; and there finally remains a less fusible alloy, consisting of tin and iron in other proportions, the iron predominating. Berthier states that a very small quantity of iron is sufficient to diminish the malleability of tin, blemish its white colour, and render it hard. The 2 metals enter into direct alloy when their oxides are heated with either charcoal or black flux. The alloy, composed of—

Tin	0·351	1 at.
Iron	0·649	4 ,,

is of a clear iron-grey colour, crystalline, and sufficiently brittle to be reduced with ease to an impalpable powder. The alloy, composed of—

Tin	0·50
Iron	0·50

is of a greyish-white colour, very brittle, with a granulated fracture. According to Bergmann, Karsten, and others, by melting iron with tin, 2 distinct and definite alloys are always obtained; the one composed of 21 tin and 1 iron; the other of 2 iron and 1 tin. The former is very malleable and harder than tin, without being so brilliant; the latter is not very malleable, and too hard to be pared with the knife.

Japanese Alloys.—(*a*) Kalischer, of Berlin, made an analysis of four Japanese alloys, with the following results:—

	a	*b*
Copper	95·77	51·10
Silver	0·08	48·93
Gold	4·16	0·12

	c	*d*
Copper	76·60	76·53
Lead	11·88	12·29
Zinc	6·53	6·68
Tin	4·38	4·36
Iron	0·47	0·33

The first, which contained much gold, had a light-red colour, with a bluish-black, lustrous patina on one side. The second, which contained silver, had a grey, almost silver-white colour, with a slight shade of yellow. *c* and *d* resembled brass in colour, and were, as the figures show, almost identical, representing a peculiar kind of bronze. Externally they were exactly alike, except that one had a fine crust outside which gave it a duller look than the metal itself. They differ from bronze in having so much lead in them, and the amount of zinc is also higher.

(*b*) H. Morin published analyses of some Chinese and Japanese bronze exhibited at Paris; like *c* and *d* above, they are distinguished by the large percentage of lead, which he found to vary between 9·9 and 20·31 per cent., while the zinc fluctuated from 0·5 to 6·0 per cent. To the large amount of lead Morin attributes the black patina which mostly characterises these bronzes. Gristofle and Bouilhet, on the one hand, confirm this view, and, on the other, prove that patina of different colours may be produced by chemical means without having recourse to bronze containing a large quantity of lead, which, as Morin himself states, is difficult to use on account of its brittleness. Morin's analyses show that in other respects the bronzes he examined bear no relation to those analysed by Kalischer.

(c) R. Pumpelly published the composition of a number of Japanese alloys, which showed the greatest conformity with the above, especially the two first mentioned. A native worker in metals allowed Pumpelly a glance into the preparation of the metals, which is generally kept secret, and he described, under the name of *shakdo*, alloys of copper and gold in which the quantity of gold varied from 1 to 10 per cent. They have a bluish-black patina, which is produced by boiling the metal or the object made of it in a solution of copper sulphate, alum, and verdigris, which removes some of the copper and exposes a thin film of gold. The action of light upon this produces the bluish-black colour, the intensity of which increases with the quantity of gold. This group can be reckoned with alloy *a* above. *Gin-shi-bui-chi* is an alloy of silver and copper, in which the amount of silver varies between 30 and 50 per cent. When boiled in the above solution, the alloy acquires a grey colour much admired by the Japanese. Alloy *b* belongs to this group. The name of *kara-haue* is given to a sort of bell-metal, consisting of copper, zinc, tin, and lead, and having some resemblance to alloys *c* and *d*.

(*d*) Maumené furnished analyses of Japanese bronzes sent home from public monuments, temples, and works of art. The alloys are granular in texture, and readily take a good polish, bringing out the true colour of the metal over large surfaces. The predominating tint is purple where much antimony is present, red where iron is the chief ingredient. These alloys have evidently been prepared with unrefined minerals. In Maumené's opinion they are to be regarded as results of the admixture of copper pyrites and antimonial galena with blende. In some, the calcination appears to have been imperfect, as shown by the sulphur present in *b* :—

	a	*b*	*c*	*d*
Copper .	86·38	80·91	88·70	92·07
Pewter. .	1·94	7·55	2·58	1·04
Antimony.	1·61	0·44	0·10	,,
Lead . .	5·68	5·33	3·54	,,
Zinc . .	3·36	3·08	3·71	2·65
Iron . .	0·67	1·43	1·07	3·64
Manganese	,,	Trace.	,,	,,
Silica . .	0·10	0·16	0·09	0·04
Sulphur .	,,	0·31	,,	,,
Loss . .	0·26	0·74	0·21	0·56
	100·00	100·00	100·00	100·00

The Japanese word corresponding to the English "bronze" is *karakane*, which means "Chinese metal"; whereas the brass alloys are called *shin-chu*. The spelter used for the latter is imported.

Jewellers' Alloys.—The following are summarised from Fesquet :—

Algiers metal : (*a*) 90 tin, 10 antimony; (*b*) 94·5 tin, 5 copper, 0·5 antimony. *a* is used for spoons and forks, *b* for small hand-bells.

Argentin : 85·5 tin, 14·5 antimony ; suitable for spoons and forks.

Ashberry metal : 78 to 82 tin, 16 to 20 antimony, 2 to 3 copper.

Blue gold : 750 gold, 250 iron ; prepared by dipping iron wire into molten gold, then casting, hammering, and passing through a draw-plate.

Britannia metal : (*a*) 9 tin, 1 antimony ; (*b*) 85 to 90 tin, 5 to 10 antimony, 0·5 to 2 zinc, 1 to 3 copper ; (*c*) 85 tin, 5 antimony, 5 bismuth, 1·5 zinc, 3·5 copper.

Chrysocale : 9 copper, 8 zinc, 2 lead.

Common jewellery : 3 refined copper, 1 old Bristol bronze, and 25 tin for every 100 copper, the tin being replaced by a compound of lead and antimony when a fine polish is needed.

Dipping metal : 48 copper, 15 zinc.

English metal : 88 tin, 2 pure copper, 2 brass (containing 75 copper, 25 zinc), 2 nickel, 1 bismuth, 8 antimony, 2 tungsten.

Feuille morte (dead leaf) : 700 gold, 300 silver.

Fine gold : 750 gold, 250 silver.

Gilding metal : 4 copper, 1 brass (containing 8 copper, 1 zinc), and 70 tin for each 80 copper.

Jewellery gold: 38·85 gold, 5·70 silver, 10·20 copper.

Mannheim gold: (*a*) 10 copper, 1·4 brass (containing 3 copper, 1 zinc), 0·1 tin; (*b*) 3 copper, 1 zinc, 0·5 tin.

Minofor: 3·25 copper, 67·50 tin, 17 antimony, 8·95 zinc.

Mock gold: (*a*) 16 copper, 7 platinum, 1 zinc; (*b*) 100 copper, 17 tin, 6 magnesia, 3·6 sal ammoniac, 1·8 quicklime, 9 bitartrate of potash; the copper is melted first, and the magnesia, ammonia, lime, and potash are successively added in small quantities; finally the tin is introduced in fragments, and the whole fused for 35 minutes.

Plate pewter: 90 tin, 7 antimony, 2 bismuth, 2 copper.

Queen's metal: (*a*) 3 to 9 tin, 1 antimony, 1 bismuth, 1 lead; (*b*) 2 copper, 50 tin, 4 antimony, 0·5 bismuth; (*c*) 24 brass (containing 7 copper, 3 zinc), 96 antimony, 30 tin; (*d*) 0·8 antimony, 18 bismuth, 32 lead.

Red gold: 750 gold, 250 copper.

Ring gold: 49·60 coin gold, 12·30 silver, 23·60 refined copper.

Tubania (Engestrum): 4 copper, 8 antimony, 1 bismuth, added to 100 tin.

Tubania (English): 12 brass (containing 7 copper, 3 zinc), 12 tin, 12 bismuth, 12 antimony.

Tubania (German): 0·4 copper, 3·2 tin, 42 antimony.

Tubania (Spanish): 24 iron and steel scraps, 48 antimony, 9 nitre; the iron and steel are heated to whiteness, and the antimony and nitre gradually added; 2 oz. of this is alloyed with 1 lb. tin; a little arsenic is an improvement.

Vert d'eau (water green): 600 gold, 400 silver.

White gold (*electrum*): gold whitened by addition of silver.

Yellow (*antique*) *gold*: pure gold.

Yellow dipping: 2 bronze (containing 7 copper, 2 tin, 3 zinc), 1 copper, and 10 tin for each 640 copper.

The following forms a fusible malleable metal, easily worked by a silversmith, resisting oxidation, and capable of being soldered: 720 parts copper, 125 nickel, 10 bismuth, 90 zinc, 20 soft iron, 20 tin.

Sauvage has introduced the following alloy: 58 copper, 27 zinc, 12 nickel, 2 tin, 0·5 alumina, 0·5 bismuth; the ingredients are fused separately, mixed, and the whole is run down into a homogeneous mass, which is silvery, sonorous, malleable, ductile, tenacious, polishes well, and does not tarnish.

As a silvery-looking alloy, Parker recommends 70 copper, 30 manganese, 20 to 35 zinc, or, if not needing to be subjected to high temperature, 49 copper, 21 manganese, 5 to 10 iron, 5 to 10 zinc. The solder used for it contains 7 copper, 3 manganese, 1 to 2 silver.

Journal Boxes.—Copper, 24 lb.; tin, 24 lb.; and antimony, 8 lb. Melt the copper first, then add the tin, and lastly the antimony. It should be first run into ingots, then melted and cast in the form required for the boxes.

Manganese Alloys.—(*a*) Manganesian iron is mixed with copper, melted in a reverberatory furnace, and run into pigs. An alloy capable of being rolled is made by melting this together with zinc and copper. For a bronze capable of being forged, protoxide of manganese and protoxide of iron, together with sufficient coal-dust to reduce the two oxides, are added to copper. After melting, the product is similar to aluminium bronze. ('Jl. Soc. Chem. Ind.')

(*b*) These alloys are very numerous, and have been given a variety of names, according to the proportions in which the metals composing them are combined; but they may be classified under 3 heads: (1) Those composed of copper and tin (gun-metal); (2) copper, tin, and zinc (bronze); (3) copper and zinc (brass).

To obtain the best effects, the ferromanganese to be used in the gun-metal alloys should be richer in manganese than that for the brass, while that for the bronze may be between the two.

and regulated as conveniently as can be by the proportions of tin and zinc employed: that is to say, if little zinc is used in the bronze alloy, the ferro-manganese employed may be nearly as rich in manganese as in the gun-metal alloys; while if the zinc predominates, the ferro-manganese employed may be a trifle richer in manganese than that used in the brass alloys; and if the zinc and tin are about equal, the quantity of manganese contained in the ferro-manganese may be between that used for the gun-metal and that used for brass alloys. The ferro-manganese used to mix with the gun-metal alloys should contain 10 to 40 per cent. of metallic manganese, while that used to mix with the brass alloys should contain about 5 to 20 per cent.; and that used for the bronze alloys should be between the two, according to the proportions of tin and zinc employed.

In selecting the ferro-manganese to be used, it should contain as little silicon as possible; when *spiegel-eisen* can be obtained of the best quality, containing but a minute quantity of silicon, and 5 to 10 per cent. of manganese, it will be suitable to mix with the brass alloys, and it may even be used with the gun-metal alloys; but it will be found advantageous to apply for both, as well as the bronze, a ferro-manganese made as follows: Procure ferro-manganese (as now manufactured for and used in steel-works) rich in metallic manganese, containing 50 to 60, or even 70 per cent.; melt this in a crucible under powdered charcoal, along with the requisite proportion of the purest wrought-iron scrap, to bring down the quantity of metallic manganese to any of the proportions before named. Supposing it is desired to employ a ferro-manganese, to mix with any of the before-named alloys, containing 20 per cent. of manganese, and a ferro-manganese, containing 60 per cent. of metallic manganese and say 1 per cent. of silicon, is melted with wrought-iron scrap in the proportion of 100 of ferro-manganese to 200 of wrought-iron scrap, a ferro-manganese containing the desired quantity of metallic manganese (20 per cent.) will be obtained, containing only ⅓ per cent. of silicon instead of 1 per cent., and so on for any other proportions required; not only this, but a still further portion of the silicon is eliminated, and the metal is refined by this second melting in a crucible as described. The quantity of ferro-manganese to be employed will vary both with the nature of the alloy and with the quality required in each particular alloy, and this will also, to a certain extent, have to be regulated by the quality of the copper, tin, and zinc employed. The purer these metals, the larger may be the quantity of ferro-manganese employed, and therefore no precise quantities can be specified; but generally, for ordinary gun-metal (composed of about 90 per cent. copper and 10 per cent. tin), ½ to 1½ per cent. ferro-manganese may be added, containing say 20 per cent. metallic manganese; and as the tin is increased, the ferro-manganese should contain more manganese and less iron.

The quantity of ferro-manganese employed should be regulated according to the purposes for which the alloy is intended to be used; generally the effect produced is with the smaller quantities named to increase the strength of the alloy and the hardness slightly; and as the quantity of ferro-manganese is increased, the hardness is also increased, but at the same time the alloy becomes more brittle. A similar effect is produced by the addition of the ferro-manganese to the brass and bronze alloys. With the brass alloys, ½ to 5 per cent. of the ferro-manganese may be employed with advantage for general purposes; and for the bronze alloys, any proportions between those for gun-metal and brass alloys may be advantageously used, these proportions being adjusted according to the quantities of tin and zinc used: that is to say, the more tin used, the less should be the quantity of ferro-manganese.

(*c*) *Manganese and Copper.* –

Berthier made several alloys of manganese protoxide and metallic copper in the proportions of 1 to 8, 1 to 4, 1 to 2, and with the manganese slightly in excess of the copper. These alloys were all ductile, the first being perfectly so, while the last, still very ductile, was also very tenacious and capable of taking a fine polish.

Experiments have been made in Paris with a new alloy having a white colour, yet containing no nickel. It is said to be very strong and malleable. It is made of copper and ferro-manganese, the proportions being varied according to the purpose to which the alloy is to be employed. An alloy of 40 parts copper and 60 of ferro-manganese, with a suitable quantity of some appropriate flux, produces a metal of such tenacity that it surpasses the best steel armour-plates. The melted mixture is cast in blocks, and is perfectly malleable. To obtain a white metal that can be rolled out in sheets, the above alloy is melted again, and 20 or 25 per cent. of zinc or white metal added, which imparts to it the desired quality. A plate of the first-named alloy, 2 in. thick, was found by experiment to offer more resistance to a cannon-ball than a steel armour-plate of the same thickness. This new kind of "white bronze" is not to be confounded with the alloy used in America under the same name for gravestones and monuments, and which consists principally of zinc. ('Polyt. Notiz.')

(*d*) "*Manganese German silver*" was made from 70 copper, 15 manganese, and 15 zinc; but as this alloy proved rather brittle in the rollers, the proportions were altered to 80 copper, 15 manganese, and 5 zinc, when a beautiful white and ductile metal was obtained, which would take a high polish.

(*e*) Of far greater importance are the "manganese tin and zinc bronzes," which were perhaps among the first upon which experiments were made on a large scale. They were obtained by adding to an alloy of copper, tin, and zinc, a certain quantity of "manganese copper," viz. the combination of 70 copper with 30 manganese, as above described, by which an increase of at least 9 per cent. of strength is obtained over the ordinary alloy. This seems to be greatly due, as in the case of the refined tough copper, to a chemical action of the manganese; for all ordinary bronzes contain more or less of copper and tin oxides, which are reduced to metal by the action of the manganese. An addition of manganese seems, however, to have also physically a strengthening effect, and an addition of 3 to 6 per cent. of manganese copper has been experimentally found to suit the purpose best.

Manganese and tin combine as readily as manganese and copper; tin, however, shows, as in ordinary bronzes, a tendency to separate itself in the middle of thick castings from the other alloys, because it remains longest in a fluid condition, and under the process of solidification it seems to get squeezed out of those parts of a casting which retain the heat longest.

An important series of experiments made at Isabelle-Hütte have shown that the strongest "manganese tin bronze" is obtained by alloying 85 copper with 6 tin, 5 zinc, and 5 manganese copper, so that the cooled product retains something above 1 per cent. manganese. The best mode of procedure is first to melt the copper in a crucible, then to add successively tin and zinc, but manganese copper only at the last moment, when the metals are well stirred up with a rod made from gas retort graphite; a reaction upon the oxides of the metallic bath is clearly noticed, as it begins to boil and to emit sparks after the addition of manganese, of which a portion is carried into the slag. On p. 69 is a table of trials made with a series of rough ingots of the metal.

The absolute strength of these alloys is considerably enhanced when the ingots are subjected to judicious forging or rolling.

No.	Cast in.	Copper.	Tin.	Zinc.	Manganese Copper.	Breaking Strength, tons per sq. in.	Limit of Elasticity, tons per sq. in.	Elongation per cent
1	sand	85	6	5	..	10·3	7·24	..
2	,,	85	6	5	4	10·34	8·4	2
3	iron	87	8·7	4·3	4	12·51	..	..
4	,,	85	6·9	5	6	12·13	..	6
5	,,	85	6	5	6	12·7	..	7
6	,,	85	6	5	10	11·05	..	5
7	sand	87	5·20	4·33	3·47	12·63	..	8·7
8	,,	87	5·20	4·33	3·47	12·7	..	8·9
9	,,	85	6	5	3	14·09	10·8	
10	,,	74	10	5 (7·66 lead)	3·3	12·06	8·9	.. ..
11	,,	78·7	8	(8 lead)	3·3	13·33	8·9	..
12	,,	82	9·8	4·9	3·3	12·7	9·5	..
13	,,	86·2	16·5	..	3·3	15·87	9·2	..

(*f*) *Delatot's white metal* is composed of 80 parts red copper, 2 manganese oxide, 18 zinc, 1 lime phosphate, fused together. To the melted copper is added the manganese in very small instalments; when this is dissolved, the lime phosphate is similarly introduced, and after the reduction has lasted ½ hour, the scum is removed from the surface of the bath, and the zinc is added about 10 minutes before running out. This alloy is said to equal gun-metal in tenacity and resistance, excel it in obviating friction, and cost much less. The fusion of the manganese oxide may be hastened by using a flux composed of 2 parts charcoal, 1 calcium fluoride, 1 sodium borate.

Medals.—50 parts copper, 4 zinc.

Muntz's Metal.—An alloy of copper and zinc. For rolling into sheets, the best proportions are 60 parts copper to 40 zinc; but for other purposes its composition is variable. It was patented in 1832 by Muntz of Birmingham, and has since superseded copper for sheathing the bottoms of ships. The alloy is made in a reverberatory furnace, the copper being melted first and the zinc added afterwards. The fused mixture is run into clay-lined vessels and ladled from these, while still hot, into iron ingot-moulds. It is rolled into sheets or worked into bolts at a red heat; the sheets are subsequently "pickled" in weak sulphuric acid, and then washed with water. Fesquet states the composition for sheathing plates as 56 copper, 40·75 zinc, 4·5 lead.

Or-Molu.—The or-molu of the brass-founder, popularly known as an imitation of red gold, is extensively used by French workmen in metals. It is generally found in combination with grate and stove work. It is composed of a greater portion of copper and less zinc than ordinary brass, is cleaned readily by means of acid, and is burnished with facility. To give this material a rich appearance, it is not unfrequently brightened up after "dipping" by means of a scratch brush the action of which helps to produce a very brilliant gold-like surface. It is protected from tarnish by the application of lacquer.

Pewter.—(*a*) Pewter is an alloy of of lead and tin, containing sometimes copper, zinc, or antimony. There are three distinct kinds of English-made pewter, viz.: (1) *Plate pewter*, used for dishes and plates, an alloy usually made without lead, and containing principally 90 parts tin, 7 antimony, 2 bismuth, and 2 copper; (2) *Trifle pewter* employed for casting drinking vessels, etc., an alloy of 82 parts tin with 18 lead, and containing variable quantities of antimony; and (3) *Ley pewter*, containing 4 parts tin and 1 lead, employed for the larger wine measures. Owing to the poisonous nature of lead, which is apt to be dissolved by the acetic acid always present in beer, the French Government has prohibited the use of an alloy containing more than 16½ per cent. of lead; if the lead be not in excess of this quantity, the tin seems to have the effect of neutralising its poisonous properties. When made in the above proportions, pewter has a specific gravity of 7·8, so that any specimens of a higher specific gravity than this may be known to contain too high a percentage of the heavier metal. Pewter is a soft metal resembling tin, but duller and darker in colour. Plates and dishes are hammered out of the variety called plate pewter, but drinking vessels, etc., are always cast into moulds from the common variety.

(*b*) Analysis of various samples showed the following compositions: —

Quality of Pewter.	Tin.	Lead	Cu.	Antimony.	Zinc.
Ordinary .	82	18	..	..	..
Good .	88·5	..	4·5	7	..
,, .	89	..	2	7	..
,, .	78	11	8·25	..	2·25
Better quality	85·5	..	..	14·5	..
Hard .	90·57	..	1·88	7·55	..
Plate .	89	..	2	7	2 Bismuth

(*c*) The following is a brief extract from a paper read before the Society of Arts by Mr. F. S. Liberty. It is still questionable, I believe, what were the precise alloys and the relative proportions used in the manufacture of ancient pewter; and, indeed, down to our own day the word "pewter" has an elastic meaning. I gather, however, that some among the old examples show a large admixture of lead, as, for instance, a vase-handle of the 4th century of our era, dug up in Rome, which, according to Bapst, was assayed in France early in the last century and found to contain about three-sevenths lead, without any trace of copper. This must, therefore, be considered as of very inferior quality. By way of explanation, it has been suggested indeed, that tin procured with difficulty from a remote and barbarous region was almost as dear as silver, and that this may account for the low grade of pewter being in use in Rome. On the other hand, however, Mr. Gowland's analysis of varying examples of Roman pewter shows that the question of cost was by no means invariably considered. His results give for what he terms "typical Roman pewter": 72·36 tin to 26·90 lead, and 70·58 tin to 27·62 lead, that is, to put it roughly, three parts tin and one part lead.

According to Mr. Welch, in the ordinances of the old English craft of pewterers, two qualities of pewter are described, the first of tin with a small admixture (supposed to be about 5 per cent.) of what is called "kettle-brass," otherwise known as "peak" metal, the peak metal being a compound of copper with some other metal not definitely ascertained, and probably always kept a mystery of the Guild. The second quality was originally called "vessel of tin," being a compound of tin and lead in the proportion of 1 cwt. of tin to not exceeding 26 lb. of lead. This alloy was afterwards known as "lay" or lead metal.

In the present day, and of late years many experiments have been made and various modifications have been tried in the composition of pewter, nearly every manufacturer having his own particular formula. For the production of modern pewter goods aspiring to be classed as artistic in design the inferior alloy containing lead is discarded altogether (except by the Japauese in the manufacture of their antimony ware). And to avoid as far as possible, the use of copper, which some consider to have a bad effect on the colour, tin is nowadays alloyed in the proportion of about 5 per cent. of antimony or bismuth, or both. An excess of copper imparts a brownish tint, whilst the use of lead (always be it remembered the alloy of the so-called second quality pewter) imparts the well-known grey-colour tone which, be it acknowledged, has for some of us a decided charm. Still, as we know, if lead is used beyond a certain proportion, it renders the pewter dangerous for the use of liquors containing acids such as beer, wine, vinegar, etc., by reason of the chemical action they set up, the excess lead producing poisonous oxides.

The old pewterers appear to have had one advantage over the modern in the fact that their lead nearly always contained a small percentage of silver, and the fascinating lustre which many old pieces of pewter possess is generally ascribed to the presence of this small proportion of silver in alloy. Modern German pewter, as compared with modern English, contains a much larger proportion of antimony, with some bismuth, and gives out when bent or bitten (which the modern English does in a far less degree) the well-known distinguishing crackle or *cri.*

Phosphor Alloys.—For the preparation of phosphorus compounds of metals, for example, phosphor-copper, Dr. Schwarz gives the following directions: A mixture of bone-ash, silica, and carbon, is placed in a crucible, and upon it a layer of granulated copper, which is in turn covered with the above mixture. The lid of the crucible is luted on. To make it melt more easily some carbonate of soda and glass may be added, or a mixture of pulverised milk-glass with charcoal and powdered coke is used for lining and covering it. Take, for example, 14 parts of silica, 88 of bone-ash, and 4 of powdered carbon. This is mixed with 4 parts of soda and 4 of powdered glass, stirred up with a little gum water, and used to line the crucible. When this is dry, the copper is put in, and covered with the same mass, and the whole is melted at a bright red heat. The copper obtained flows well, and has a reddish-grey colour. It contains 0·50 to 0·51 per cent. of phosphorus.

The simplest method for introducing phosphorus into bronze is to stick a bar of the phosphorus into a tube of pinchbeck, one end of which is hammered together, and closed tightly. After the phosphorus is put in, the other end is closed too. When the metal, which contains 32 parts of copper to 5 of zinc and 1 of tin, is melted, the tube charged with phosphorus is pushed down in it to the bottom of the crucible by means of bent tongs. The stick of phosphorus must always be kept under water until it is about to go into the pinchbeck tube, when it must be carefully dried, as the presence of any moisture would be sure to cause the metal to spurt or fly about.

Another way of introducing the phosphorus is as follows: Get about 2 ft. of iron barrel from a gas-fitter, the bore, a little larger than the sticks of phosphorus; make an iron-plug to closely fit the bore, and then drive it down one end of the pipe until the space remaining will hold the quantity of phosphorus you wish to mix in the bath, minding not to split the barrel in driving in the plug. Make a plug of tin about ½ in. thick to fit in the bore; now introduce your phosphorus into the space formed by the iron plug, and just tap the tin plug into the end of the barrel with a hammer. Stir the tin-plugged end about in the molten metal; the tin plug soon melts, letting out the phosphorus in the bronze bath.

In 1868, Montefiore and Künzel, of Liége, Belgium, observed that the tin in bronze progressively decreases by oxidation during smelting, the tin oxide going partly into the slag and being partly dissolved in the molten metal, so that bronze originally composed of 10·10 per cent. tin and 89·90 copper, after the 4th melting contained only 8·52 tin and 91·48 copper. It was found that "poling" (stirring up the molten metal with a wooden stick) eliminated the oxide combined with copper, but had no effect on the tin oxide. Künzel then tried the introduction of a little phosphorus, or phosphuret of tin or copper, into the mass, with the desired result. Bars cast from the same crucible of metal under the three conditions named gave the following figures:—

Conditions of the Mass of Metals.	Resistance.		Lengthening until Rupture.
	Absolute Lb. per Square Inch.	Elastic Lb. per Square Inch.	
			per cent.
Old bronze	22,982	17,020	2·0
,, poled	24,922	17,709	2·8
,, deoxidized with phosphorus	33,916	19,300	6·8

Other experiments in phosphorising alloys of copper, nickel, manganese, and iron, were not satisfactory; nor was that of using sodium instead of phosphorus as a deoxidiser. The action of phosphorus in bronze is (1) to eliminate the oxides, and (2) to make the tin capable of assuming crystalline structure, thus increasing the homogeneity of the alloy, and thereby its elasticity and absolute resistance. Among other properties, phosphor-bronze emits sparks under friction much less readily than gun-metal or copper; it is peculiarly adapted for friction-bearing; is easily rolled into sheets, and is very tough in that form; and oxidises in sea-water at about one third the rate of copper.

Phosphor Bronze, which is largely used as a substitute for bronze and gun-metal compositions, for gearing, bearings, wire rope, etc., is an alloy of copper and tin, which has been fluxed by the introduction of a variable quantity of phosphorus, which is generally added in the form of phosphide of copper or phosphide of tin. *Phosphide of copper* is prepared by heating a mixture of 4 parts of super-phosphate of lime, 2 parts of granulated copper and 1 part of finely pulverised coal in a crucible at not too high a temperature.

Pinchbeck.—Copper, 5 lb.; zinc, 1 lb.

Pipe Metal for Organs.—(*a*) Melt equal parts of tin and lead. This alloy is cast instead of rolled in the desired form of sheets, in order to obtain a crystallised metal, which produces a finer tone. The sheets are formed by casting the metal on a horizontal table, the thickness being regulated by the height of a rib or bridge at one end, over which the superfluous metal flows off. The sheets thus obtained are planed with a special plane, bent up and soldered.

(*b*) The alloy is lead and tin from 70 of lead and 30 of tin for the cheapest to 10 of lead and 90 of tin for the best quality.

Queen's Metal.—A very fine silver-looking metal is composed of 100 lb. of tin, 8 of regulus of antimony, 1 of bismuth, and 4 of copper.

Rivet Metal.—(*a*) Copper, 32 oz.; tin, 2 oz.; zinc, 1 oz.

(*b*) Copper, 64 lb.; tin, 1 lb.

Silver Alloys.—(*a*) De Ruolz and Fontenay have invented the following alloy, which may be used for almost all purposes for which silver is usually employed: Silver, 20 parts; purified nickel, 28 parts; copper, 52 parts. Melt the copper and nickel in the granular state, then introduce the silver. The flux to be employed is charcoal and borax, both in the state of powder; and the ingots obtained are to be rendered malleable by annealing for a considerable time in powdered charcoal.

(*b*) Copper, ½ oz.; brass, 2 oz.; pure silver, 3 oz.; bismuth, 2 oz.; saltpetre, 2 oz.; common salt, 1 oz.; arsenic, 1 oz.; potash, 1 oz.; melt in a crucible with powdered charcoal.

Soft Alloy.—(*a*) This alloy will adhere so firmly to metallic, glass, and porcelain surfaces, that it can be used as a solder, and is invaluable when the articles to be soldered are of such a nature that they cannot bear a high degree of temperature. It consists of finely pulverised copper or copper-dust, and is obtained by precipitating copper from the sulphate by means of metallic zinc: 20, 30, or 36 parts of this copper-dust, according to the hardness desired, are placed in a cast-iron or porcelain-lined mortar, and well mixed with some sulphuric acid having a specific gravity of 1·85. Add to the paste thus formed 70 parts (by weight) of mercury, constantly stirring. When thoroughly mixed, the amalgam must be carefully rinsed in warm water to remove the acid, then laid aside to cool. In 10 or 12 hours it will be hard enough to scratch tin. When it is to be used, it should be heated to a temperature of 707° F. (375° C.), when it becomes as soft as wax by kneading it in an iron mortar. In this ductile state it can be spread upon any surface, to which, as it cools and hardens, it adheres very tenaciously.

(*b*) *For Small Articles.*—This alloy melts at a lower degree of temperature than the one just described, and is very hard without being brittle. It consists of 6 parts bismuth, 3 zinc, and 13 lead. The 3 metals, after having been well melted and stirred together, should be poured into another melting-pot, and melted again. This alloy cools with remarkably clear cut edges, and if the articles made of it are dipped in dilute nitric acid, then rinsed in clear water, and polished with a woollen rag, the raised parts of the surface will have a fine polish, while the sunken parts will have a dark grey, antique appearance, which forms a pretty contrast. The proportions of the different metals, dividing the alloy into 100 parts, are: 27·27 bismuth, 59·09 lead, 13·64 zinc.

(*c*) *For Small Castings.*—Contains 6 parts bismuth, 3 tin, 13 lead. This alloy should be melted, run into bars, and laid aside till wanted, when it should be remelted. An alloy of 3 parts bismuth, 1 tin, 1 lead, for small castings, is harder, and yet it is not brittle. It can be finished with a contrasting surface of bright polish and dark grey, if it is washed in nitric acid, well diluted, rinsed, and polished with a woollen rag as described in the alloy for small articles given above.

Solders.—Alloys employed for joining metals together are termed "solders," and they are commonly divided into two classes: hard and soft solders. The former fuse only at a red heat, but soft solders fuse at comparatively low temperatures.

One of the most easily fusible metals is an alloy of 2 parts bismuth, 1 tin, and 1 lead; tin is the most fusible of these three metals, melting at 455° F. (235° C.); but this alloy melts at 199½° F. (93° C.), or a little below the boiling point of water. By diminishing the quantity of bismuth in the alloy, the point of fusion may be made to vary between 212° F. (100° C.) and 329° F. (200° C.), and thus it is an easy matter to form a solder which shall fuse at any required temperature between these limits, for electrical purposes, steam-boiler plugs, etc. The following are the best recipes for the common solders: For ***aluminium-bronze***: (*a*) 88·88 gold, 4·68 silver, 6·44 copper; (*b*) 54·4 gold, 27 silver, 18·6 copper. (*c*) Melt 20 parts of aluminium in a suitable crucible, and when in fusion add 80 of zinc. When the mixture is melted, cover the surface with some tallow, and maintain in quiet fusion for some time, stirring occasionally with an iron rod. Then pour into moulds. (*d*) 15 parts aluminium and 85 of zinc; (*e*) 12 aluminium and 88 zinc; (*f*) 8 aluminium and 92 zinc; all of these alloys are prepared as (*c*). The flux recommended consists of 3 parts copaiba balsam, 1 of Venetian turpentine, and a few drops of lemon-juice. The soldering-iron is dipped into this mixture.

For *brasswork*: (*a*) equal parts of copper and zinc; (*b*) for the finer kinds of work, 1 part silver, 8 copper, 8 zinc.

For *copper*: (*a*) 3 parts copper, 1 zinc; (*b*) 7 copper, 3 zinc, 2 tin.

Hard solder: 86·5 copper, 9·5 zinc, 4 tin.

Hard solder for gold: 18 parts 18 carat gold, 10 silver, 10 pure copper.

Hard silver solder: (*a*) 4 parts silver, 1 copper; (*b*) 2 silver, 1 brass wire; these are employed for fine work; the latter is the more readily fusible; (*c*) equal parts copper and coin silver; requires higher temperature than *b*, but will not "burn," is as fluid as water, and makes a far sounder joint.

Hard spelter solder: 2 parts copper; 1 zinc; this solder is used for ironwork, gun-metal, etc.

For *jewellers*: (*a*) 19 parts fine silver, 10 brass, 1 copper; (*b*) for joining gold, 24 parts gold, 2 silver, 1 copper.

Middling hard solder: 4 parts scraps of metal to be soldered, 1 zinc.

For *pewterers*: (*a*) 2 parts bismuth, 4 lead, 3 tin; (*b*) 1 bismuth, 1 lead, 2 tin; the latter is best applied to the rougher kinds of work.

For *sealing iron in stone*: 2 lead, 1 zinc.

For *sealing tops of canned goods*: 1½ lb. lead, 2 lb. tin, 2 oz. bismuth; the lead is melted first, the tin added next, and finally the bismuth stirred in well just before pouring. This makes a soft solder, and the cans do not take much heat to open them.

Soft solder: 1 lead, 2 tin.

Soft solder for joining electrotype plates: 67 parts lead, 33 tin.

For *steel*: 19 parts silver, 3 copper, 1 zinc.

For *tinned iron*: 7 lead, 1 tin.

Specular Alloys.—These are employed for making metallic reflectors, requiring a true white colour, good lustre, and a hard, clean surface not easily tarnished or scratched. Fesquet gives a number of combinations, as follows:—

(*a*) 62 parts copper, 32 tin, 6 lead; (*b*) 80 copper, 10 lead, 10 antimony; (*c*) 66 to 63 copper, 33 to 27 tin; (*d*) 10 copper, 10 tin, 10 antimony, 50 lead; (*e*) 32 copper, 50 tin, 1 silver, 1 arsenic; (*f*) 90 steel, 10 nickel; (*g*) 50 palladium, 50 silver; (*h*) 60 platinum, 40 copper; (*i*) 50 platinum, 50 steel; (*j*) 50 platinum, 50 iron; (*k*) 10 platinum, 90 steel; (*l*) 20 platinum, 80 copper, 0·5 to 1 arsenic; (*m*) 60 platinum, 30 iron, 10 gold; (*n*) 50 gold, 50 zinc; (*o*) 50 steel, 50 rhodium; (*p*) 10 platinum, 90 iridium; (*q*) 29 tin, 19 lead; (*r*) 52 copper, 30 nickel, 12 zinc, 5 lead, 1 bismuth.

(*s*) Equal parts of tin and copper form a white metal as hard as steel. (*t*) Less tin and a small quantity of arsenic added to the alloy forms a white hard metal of high lustre. (*u*) 2 lb. copper, 1 lb. tin, 1 oz. arsenic form a good speculum metal. (*v*) An alloy of 32 copper, 16·5 tin, 4 brass, 1·25 arsenic, is hard, white, and of brilliant lustre.

Statuary Metal.—(*a*) 91·4 parts copper, 5·53 zinc, 1·7 tin, 1·37 lead. (*b*) Copper 80, tin 20.

Stereotype Metal.—1 tin; 1 antimony; 4 lead.

Sterro-Metal.—This is a very strong and elastic alloy used by Austrian engineers for hydraulic press pumps. It contains copper, zinc, iron and tin, in the following proportions:—

Copper	55 to 6[illegible]
Zinc	34 ,, 44
Iron	2 ,, 4
Tin	1 ,, 2

Good specimens offer far more resistance than gun-metal to transverse fracture, and cost only ⅜ the price. It is said to have been discovered in an attempt to employ, for the manufacture of brass, the alloy of iron and zinc found at the bottom of the zinc-pots in making galvanised iron.

Tombac.—(*a*) Copper, 16 lb.; tin, 1 lb.; zinc, 1 lb.

(*b*) Red. Copper, 10 lb.; zinc, 1 lb.

Tungsten Bronzes.—In the arts, tungsten bronzes of different colours are used, namely, golden-yellow, reddish-yellow, purple-red, and blue. The first two crystallise in forms resembling cubes, while the third is obtained partially in cubes and partially in amorphous pieces, and the last-named forms prismatic crystals. Other circumstances being equal, the yellow bronze is obtained from mixtures poor in acid, the other two from those containing more acid. But the colour is dependent not merely on the composition of the soda tungstate salt, but also on the amount of tin, and on the duration of the fusion; so that when much tin is used, and the fusion is prolonged, a yellow bronze is obtained from a very acid mixture, and, on the contrary, a salt that is but slightly acid, when fused only a short time and with very little tin, may yield a red or even a blue bronze.

A mixture in the proportion of two molecules of soda tungstate and 1 of anhydrous tungstic acid, with tinfoil slowly added, and kept melted for 1 or 2 hours, will yield cubes 1/5 in. long when about 4 oz. are melted, and they will produce a yellow or reddish-yellow bronze, the powder of which seems light brown, and when stirred up with water it imparts to the liquid the property of appearing of a fine blue colour by transmitted light.

The red bronze obtained from 10 parts soda carbonate, 70 soda tungstate, and 20 tinfoil yields, on pulverisation, a powder that, stirred up in water, transmits green light.

According to J. Philipp, a blue bronze is always obtained, if the fused mixture contains more than 3 molecules of tungstic acid to 1 of soda; if the fused product is boiled alternately with muriatic acid and with carbonate of soda, the result will be a considerable quantity of fine blue prismatic crystals, with which there are intermixed, in most cases, single red and yellow cubes.

Moreover, all the tungsten bronzes obtained by fusion with tin can also be prepared by electrolysis of fused acid tungstates, but the yield is so small that it is unprofitable. ('Ind. Zeit.')

Tutania.—(*a*) Iron or steel, 8 oz.; antimony, 16 oz.; nitre, 3 oz. Melt and harden 8 oz. tin with 1 oz. of this compound.

(*b*) Antimony, 4 oz.; arsenic, 1 oz.; tin, 2 lb.

Type-metal.—(*a*) This alloy, used for printer's type, is often composed of 6 parts lead, and 2 antimony. It is of a blackish-grey colour, and is softer than tin and copper, but a little harder than lead. Several of these alloys, having the following compositions by weight:—

Lead	86·21	80	75
Antimony	13·79	20	25
	100	100	100

have been submitted to a new examination by F. de Jussieu, who published his results in a pamphlet. The chief portion of this is devoted to the experimental recognition and exposition of facts of interest to the purely scientific metallurgist, and especially in reference to the liquation and crystallisation upon reduction of temperature of these alloys; but there are a few things intercalated which may prove of practical importance. Amongst these is the fact that those alloys of lead and antimony, whose constituents are the same in kind as common type-metal, are susceptible of assuming a high degree of hardness when rapidly cooled against a cold metallic surface, showing a perfect analogy with the property of hardening by chilling eminently possessed by certain cast-irons, but more or less shown by all known varieties of that metal. ('Engineer.')

(*b*) 9 parts lead to 1 antimony forms common type metal; 7 lead to 1 antimony is used for large and soft type; 6 lead and 1 antimony for large type; 5 lead and 1 antimony for middle type; 4 lead and 1 antimony for small type; and 3 lead to 1 antimony for the smallest kinds of type.

(*c*) Fesquet gives the following combinations:—

Large type: (*a*) 10 lead, 2·5 copper; (*b*) 9 lead, 1 antimony, 0·5 arsenic; (*c*) 8 copper, 2 tin, 0·5 bismuth; (*d*) 2 copper, 2 tin, 2 bismuth; (*e*) 73 copper, 27 zinc; (*f*) 5 copper, 67 zinc, 25 tin, 3 nickel; (*g*) 12 tin, 16 zinc, 64 lead, 8 antimony.

Music plates: (*a*) 5 to 7·5 tin, 5 to 2·5 antimony: (*b*) 16 lead, 1 antimony; (*c*) 8 lead, 2 antimony, 1·5 tin; (*d*) 4 lead, 2 antimony, 1 zinc; (*e*) 7·5 lead, 2·5 antimony, 0·5 copper.

Printing type: 4 parts lead, 1 antimony.

Small type and Stereotypes: (*a*) 9 parts lead, 2 antimony, 2 bismuth; (*b*) 16 lead, 4 antimony, 5 tin. (*c*) For every 6 lb. of lead add 1 lb. antimony. The antimony should be broken into very small pieces, and thrown on the top of the lead when it is at red heat. The cheapest and simplest mode of making a stereotype metal is to melt old type, and to every 14 lb. add about 6 lb. of grocers' tea-chest lead. To prevent any smoke arising from the melting of tea-chest lead, it is necessary to melt it over an ordinary fire-place, for the purpose of cleansing it, which can be done by throwing in a small piece of tallow about the size of a nut, and stir it briskly with the ladle, when the impurities will rise to the surface, and can be skimmed off. In the mixing of lead and type-metal, see that there are no pieces of zinc amongst it, the least portion of which will spoil the whole of the other metal that is mixed with it. Zinc is of a bluish-white colour; its hue is intermediate between that of lead and tin. It takes about 80° more heat than lead to bring it into fusion; therefore should any metal float on the top of the lead, do not try to mix it, but immediately take it off with the ladle.

White Metal.—(*a*) Tin, 82; lead, 18; antimony, 5; zinc, 1; and copper, 4 parts.

(*b*) Hard. Sheet brass, 32 oz.; lead, 2 oz.; tin, 2 oz.; zinc, 1 oz.

White Alloy.—This compound can be turned, filed, and bored; does not adhere to the mould, and will retain its polish a long time after exposure to the air. Contains 10 cast-iron, 10 copper, 80 zinc.

Birmingham Platinum.—This is a white alloy for buttons, and consists of copper, 43 per cent.; zinc, 57. Other alloys for white buttons are: (1) Yellow brass, 32 parts; zinc, 8; tin, 1. (2) Yellow brass, 32 parts; zinc, 4; tin, 2.

Chinese White Copper.—Copper, 40·4; nickel, 31·6; zinc, 25·4; and iron, 2·6 parts.

Alloy Resembling Silver.—Copper, 75 parts; nickel, 16; zinc, 2¼; tin, 2¾; cobalt, 2; iron, 1½; aluminium, ½.

Fahlun or Tin Brilliants.—An alloy of especially fine lustre which is used for stage jewellery consists of tin, 3 parts, and lead, 2, or of tin, 3 parts, and lead, 1. For the production of brilliants melt small portions of the alloy in an iron crucible. By dipping into the fluid mass, previously freed from every particle of oxide, pieces of glass or brass, ground like brilliants and highly polished, a thin layer of metal adheres to them which, after cooling, can be readily detached. The separate pieces may be connected by soldering. Sometimes the alloy is poured into moulds faceted in the same manner as diamonds.

Victor Metal.—A white metal has been on the market for some time under this name. It is used for sand-casting, and is excellent for marine work, as it withstands the action of sea-water as well as any of the zinc alloys. It has a whiter colour than German silver. The following analysis was made of a sand-casting of this metal: Copper 49·94 per cent., zinc 34·27 per cent., nickel 15·40 per cent., aluminium ·11 per cent., iron ·28 per cent.

The iron is present as an impurity. It will be seen that the alloy contains a large amount of zinc. This renders the mixture cheap. As so much zinc is present, the alloy is hard, although quite strong. Great care must be used in making the mixture not to exceed the percentage of alumininum which is given, or brittleness will result. Two ounces of aluminium to 100 lb. of metal are all that are necessary. If one desires to duplicate the mixture, the following may be taken: Copper 50 lb., zinc 35 lb., nickel 15 lb., aluminium 2 oz.

The nickel and copper are melted together under borax, and then the aluminium added. The zinc is next added. The metal is poured into ingots, and gives better results after having been melted once. This mixture is too hard for rolling into sheet. ('The Brass World.')

Zinc Bronzes (Fontaine Moreau).

Zn.	Cu.	Fe.	Pb.
90	8	1	1
91	8	..	1
92	8	..	..
92	7	1	..

The above may be considered the maximum of zinc and minimum of copper that will cast free of crystalline fracture. By lessening the zinc from 1 to 4 per cent. and increasing the copper one-eighth to one-sixth, a better texture may be looked for.

Miscellaneous.—The following is a table of the proportions of the various metals in the alloys most commonly employed in the arts and manufactures. The term "parts" means parts by weight. The abbreviations are: Cu, copper; Zn, zinc; Sn, tin; Pb, lead; Sb, antimony; P, phosphorus; As, arsenic; Ni, nickel.

Description.	Cu.	Zn.	Sn.	Pb.	Sb.	P.	As.	Ni.
Metal for frictional parts of locomotives (extremely hard)	87	5	8	..	..	..	..	..
Bearings of carriages	97	3	..	..	..	..	..	..
Bearings of driving wheels, also for steam-engine whistles giving a clear sound	80	2	18	..	..	..	..	..
Steam-engine whistles giving a deep sound	81	2	17	..	..	..	..	..
Cross-heads of connecting-rods	82	2	16	..	..	..	..	..
Cylinders of pumps, valve-boxes, and taps	88	2	10	..	..	..	..	..
Eccentric collars	84	2	14	..	..	..	..	..
Bearings of axles and trunnions; eccentric collars	84	2	14	..	..	..	..	..
	85	2	13	..	..	..	..	..
	84	7	9	..	..	..	..	..
	68	4	28	..	..	..	..	..
Pistons of locomotives	88	9	3	..	..	..	..	..
	84	8·4	2·9	4·7	..	..	..	..

Description.	Cu.	Zn.	Sn.	Pb.	Sb.	P.	As.	Ni.
Axle-boxes	88	2	10	..	..	..	..	..
Mathematical instruments, arms of balances	90	2	8	..	..	..	..	..
Machinery bearings, etc.	67	..	14	19	..	..	..	..
Steam-engine whistles	30	..	18	..	2	..	..	..
Metal to withstand friction (Stephenson)	79	5	8	8	..	..	..	..
Rivets	64	24·6	3	9	..	..	..	..
Metal for coffins	15	..	40	45	..	..	..	..
Metal to withstand friction	2	..	72	..	26	..	..	..
Cylinders of pumps	7	72	21	..	..	..	..	..
Metal for bearings of locomotives	2	..	90	..	8	..	..	..
White brittle metal (for buttons, etc.)	10	6	20	..	64	..	..	..
Imitation silver	64	..	3	..	..	..	..	..
Pinchbeck	5	1	..	..	..	..	..	..
Tombac	16	1	1	..	..	..	..	..
Red tombac	10	1	..	..	..	..	..	..
Specially adapted for bearings	83	..	15·5	..	1·5	..	..	..
For bearings and valves	83·25	..	7	9	..	·75	..	..
Electrotype "backing metal"	..	..	4	91	5	..	..	..
Stereotype metal for paper process	..	..	..	88	12	..	..	..
,, ,, for plaster process	..	..	..	82	18	..	..	..
Bullet metal	..	..	..	92	..	..	2	..
Malleable brass plate	67	33	..	·5	..	..	..	..
Pin wire	67	33	·5	·5	..	..	..	..
Jemmapes brass	64·6	33·7	·2	1·5	..	..	..	..
Similor for gilding	92·7	4·6	2·7	..	..	..	..	..
Maillechort for rolling	60	20	..	..	..	..	..	20
,, first quality	8	3	..	..	..	..	..	4
White similor	7	..	..	..	..	..	·5	..
For stopcock seats	..	..	86	..	14	..	..	..
,, ,, plugs	..	..	80	..	20	..	..	..
For keys of flutes, etc.	..	..	..	20	40	..	..	..
Hard tin	..	..	1	..	0·5	..	..	..
White tombac	75	..	25	..	..	..	..	..
Vogel's alloy for polishing steel	8	1	2	1	..	..	..	..
Rompel's anti-friction metal	62	10	10	18	..	..	..	..
Arguzoid, a tough alloy superior to brass	56	23	4	3½	..	..	..	13½

ALUMINIUM PAPER.

(*a*) THE French Aluminium Co. have conducted a number of experiments on the manufacture of aluminium paper, for the use of packages containing foods, etc. The paper is coated on one side only, so that there can be no metal in contact with the substance contained in the parcel.

Two machines are employed. One of them receives the raw paper in rolls for preparation. It comprises a number of cylinders and a trough in which the colour is mixed with the gelatine or casein. To make metallised paper the liquid contains metallic dust in suspension which is deposited on the paper with the colour. Brushes worked by the machine itself spread out the coat evenly. Then the paper continuing in motion is drawn towards the dryer. The latter has a double rolling track supported on pillars and constituted by two endless chains running across the building lengthwise four times. When the paper leaves the machine it is supported by a stick, which automatically places itself on spurs fixed at intervals on the chains. Thus the paper is carried by a large number of sticks which are drawn through the dryer at a uniform rate of speed. Finally, after travelling about 500 metres, the paper is collected on a reel and conveyed to the calenders and, if necessary, goffered.

(*b*) By the Wickel process great improvements have been effected, as by it papers of all thicknesses can be treated.

The paper is first of all coated with a varnish of suitable resins dissolved in ether or alcohol; it is then drawn by heated rollers under a narrow trough equal in length to the width of the paper, from which the metallic dust is uniformly shaken down and deposited on the paper, any excess of dust being drawn off by a suitable aspirator. By this process the metal is protected from corrosion by the varnish, and therefore retains its value as a protective coating of the paper. When calendered and goffered, the paper is suitable for all kinds of purposes. Cotton cloth or silk can also be metallised with equal facility by this process. ('World's Paper Trade Review.')

◆

AMALGAMS.

MERCURY unites with a large number of metals, forming definite chemical compounds called "amalgams." Some of these are solid, while others exist in a fluid state. It is probable, however, that fluid amalgams merely represent a solution in excess of mercury of some fixed compound of mercury with another metal, inasmuch as when a quantity of such fluid amalgam is pressed through the pores of a chamois-leather bag, a small portion of mercury passes through leaving behind the solid amalgam, which, on examination, is generally found to have a fixed chemical constitution. The fluidity of an amalgam seems, therefore, to depend upon the presence of an excess of mercury over and above the amount theoretically required to enter into combination with the other metal.

The chemical affinity which causes mercury to combine with other metals is generally of a feeble character. Gentle pressure will drive out a considerable quantity of the combined mercury leaving a combination in altogether different proportions from the original one. A moderate heat also is sufficient to decompose almost any amalgam. This fact was formerly made use of in the process known as *water-gilding*. The article to be gilded was covered with an amalgam of gold with excess of mercury, and then subjected to a strong heat. The mercury was driven off, leaving the article covered with a fine coating of metallic gold, which, on burnishing, regained its lustre.

The following are some of the most important amalgams :—

Copper Amalgam.—There are several methods of preparing this, the following being, perhaps, the best: A mixture of finely-divided metallic copper (obtained by precipitating copper sulphate with metallic iron) and mercurous sulphate is triturated under hot water for ½ hour. After this, the water is repeatedly changed until it is no longer blue. The mass is then dried, kneaded well and allowed to harden, when it consists of an amalgam of 7 parts mercury with 3 of copper. The peculiarity of this amalgam is its property of softening when kneaded, and becoming quite hard again after standing some hours. It has been used by Parisian dentists as a stopping for decayed teeth, though, owing to the poisonous nature of the copper, it is not to be recommended for this purpose.

Gold Amalgam.—This is formed when mercury is heated with powdered gold or gold-foil. It consists usually of 2 parts of gold to 1 of mercury. It has been found native near Mariposa, in California, and in the platinum region of Colombia.

The readiness with which mercury combines with gold is made use of in the extraction of the latter from its ores. The ore is crushed in an iron mortar, or battery, as it is termed. Water is introduced into each battery by a number of pipes. Mercury is placed in the batteries in small quantities, and unites with the gold, as the latter is liberated by the crushing process. The larger portion of the amalgam is afterwards found in the batteries, adhering to the plates, the remainder being caught by inclined plates placed outside the battery. The plates are cleaned by scraping off the adhering amalgam, first gently with a knife, and finally with a thick piece of hard gum or rubber, which scrapes the surface closely without cutting or scratching it. The plates are then washed with water, and prepared for use again by sprinkling mercury over them, and spreading the same evenly by means of a cloth, thus forming a freshly amalgamated surface.

Iron Amalgam.—Iron will not unite with mercury under ordinary conditions. Small quantities of an iron amalgam have, however, been formed by immersing sodium amalgam (containing 1 per cent. sodium) in a clear, saturated solution of ferrous sulphate.

For coating Plastic Castings.—1 part tin, 1 mercury, 1 bismuth. The mercury is mixed with the white of an egg, and added to the tin and bismuth when they are thoroughly melted and blended. The alloy while still hot forms a pasty liquid, which should be applied with a brush. (Güttier.)

Silver Amalgam.—This compound is formed by the union of mercury with finely-divided silver. Native silver amalgam has been found at Moschellandsberg, in the Palatinate, and in several other places. Mercury is used for silver extracting, in a process somewhat similar to that described above for the extraction of gold.

Sodium Amalgam.—Sodium and mercury combine readily under ordinary conditions by being brought into contact one with another. The union is attended with much hissing and spluttering, and with a considerable evolution of heat.

Tin Amalgam.—Tin and mercury combine readily at ordinary temperatures. If 3 parts mercury be brought into contact with 1 of tin, 6-sided crystals of tin amalgam are formed. Tin amalgam is used for silvering looking-glasses. When pulverised and rubbed on the polishing-stone, it forms a kind of mosaic silver. Electric amalgam may be made by melting tin and zinc together in various proportions in a porcelain crucible. The mixture is well stirred up, and when on the point of solidifying, the mercury is added, and worked into the mass. The whole is next transferred to a mortar warm enough to keep the amalgam soft while it is well worked together, after which a piece of tallow or lard, not quite equal in bulk to the mass, is kneaded in until the amalgam attains the proper consistency.

Zinc Amalgam is formed by mixing and triturating zinc filings with mercury, at a heat somewhat below the boiling-point of the latter. It is usually prepared by pouring mercury into zinc at the temperature at which the latter is just kept in a fused state. Care must be taken to keep the liquid stirred, and to add the mercury slowly, and in as fine a stream as possible.

AMBER.

(*See also* CELLULOID.)

Working.—Amber in the rough is first split and cut rudely into the shape required by a leaden wheel worked with emery powder, or by a bow-saw having a wire for the blade, tripoli or emery powder being used with it. The roughly-formed pieces are then smoothed with a piece of whetstone and water. The polishing is effected by friction with whiting and water, and finally with a little olive oil laid on and well rubbed with a piece of flannel, until the polish is complete. In this process the amber becomes hot and highly electrical; as soon as this happens it must be laid aside to recover itself before the polishing is continued, otherwise the article will be apt to fly into pieces.

Mending.—Smear the parts which are to be united with linseed oil, hold the oiled part carefully over a small charcoal fire, a hot cinder, or a blue gas flame, being careful to cover the rest of the object loosely with paper; when the oiled parts have begun to feel the heat, so as to be sticky, pinch or press them together, and hold them so till nearly cold. Only that part where the edges are to be united must be warmed, and even that with care, lest the form or polish of the other parts should be disturbed; the part joined generally requires a little repolishing.

Imitation.—A recipe by Roessler is to melt two parts (by weight) of rosin, then add four parts of shellac. When these two are in a fluid state add two parts of pure clear white rosin.

ANEMOMETERS, AND THE DETERMINING OF AIR CURRENTS.

(*See also* CHIMNEYS; VENTILATION; ETC.)

THE various methods that have been employed for this purpose may be divided into three groups.

First.—By moving at the same velocity as the current, and noting the distance passed over in a unit of time.

Second.—Determining from observation the rate at which small floating particles are carried along by the current, and assuming their velocities to be identical with that of the air-current itself. Smoke from exploded gunpowder, burning turpentine or amadou, small pieces of down, and small balloons filled with hydrogen, have been all more or less employed for this purpose.

Third.—By using anemometers, or apparatus of various forms; and these may be divided into three classes: (*a*) Anemometers having vanes or wands, made to *revolve* by the current of air impinging upon them, the rate at which they revolve being indicated by pointers on dials forming a part of the instrument—the pointers being made to revolve by means of wheels connecting them with the axis of the vanes or wands. The anemometers of Biram and Davis are instances of this class of instruments now in use in this country, all of which require a correction for friction. (*b*) Instruments which are affected by the *force* or impulse of the wind, without being subjected to any continuous revolving motion, such as Dr. Lind's, Henaut's, Bougier's, and Dickinson's anemometers.

In modern practice determination of air velocities are made only by the anemometer, and it is therefore unnecessary to give further particulars of the first and second methods.

Anemometer. — The simplest form is that invented by Benjamen Biram, shown in Fig. 15. It consists of a series of vanes, D, E, which revolve with the action of the air-current —the number of revolutions, or rather numbers proportional to the revolutions, being registered by a pointer, P, on the face of a dial forming a part of the instrument itself. It is made of three sizes, 4, 6, and 12 in.; is very portable, and is not, with proper care, liable to get out of order, especially the smaller size. A certain force of current is required to overcome the friction, and put the instrument into motion. Some of these instruments will continue to revolve in a current as low as 30 ft. a minute; but with most of them a velocity of about 50 ft. is required.

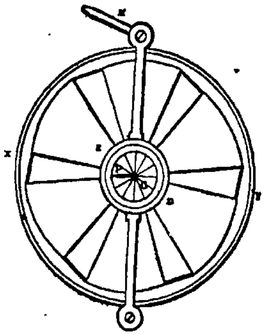


FIG. 15.

Every one who has occasion to use this anemometer should be aware that it does not register the actual velocity of the air, especially in feeble air-currents, nor yet the number of revolutions, but only a number proportional to the latter; and although it is of great value, as indicating an increase or decrease in the velocity, from time to time, such as the periodical variations in any particular current, it is of comparatively little value *as generally used* for ascertaining real velocities, such, for instance, as occur in changing or splitting air-currents, when it is of great importance to know the actual quantities. To obtain with this instrument accurate results, available for all purposes, it is necessary, as with Combes' anemometer, to apply a formula to its recorded revolutions, or rather to the number indicated by the index, in order to ascertain the actual velocity of any current; each particular instrument requiring special experiments to be made with it, in order to determine the value of the constants required to be employed in the formula. These constants remain the same for the same instrument, so long as it remains in the same condition, and are independent of the velocities of the currents of air in which it is employed. These adjustments are carefully made by the manufacturer.

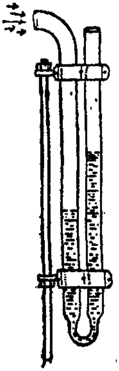


FIG. 16.

Lind's Anemometer. —(*a*) The raising of a column of fluid above the general level of its surface is the principle of Dr. Lind's anemometer, Fig. 16. It consists of two glass tubes about 9 inches long and $\frac{4}{10}$ths of an inch in diameter, connected at their lower extremities by another tube of glass only $\frac{1}{10}$ of an inch in diameter. The upper extremity of one tube is either bent over as shown, or is fitted with a thin metal cap, at right angles, so that its mouth may receive the current of air in a horizontal direction. Water is poured in at the mouth till the tubes are nearly half full, and a scale of inches and parts of an inch is placed between the tubes. When the wind blows in at the mouth of the tube the column of water is depressed in this tube, and elevated to a similar extent in the other tube, so that the distance between the surfaces of the fluid in each tube is the length of a column of water, the weight of which is equal to the force of the wind upon a surface equal to the base of the column of fluid. The object of the small tube which connects the two larger ones is to prevent the oscillation of the fluid by irregular blasts of wind. The absolute velocity of the wind is

TABLE OF THE FORCE AND VELOCITY OF DIFFERENT WINDS FOR THE GRADUATION OF ANEMOMETERS.

Height of the column of water in Dr. Lind's Anemometer.	Force on a sq. ft., in pounds avoirdupois	Force on a sq. ft. in pounds, ounces, and drams, avoirdupois.			Feet in one second	Miles in one hour	Feet in one second	Miles in one hour	Character of the Winds.	
					Computed from Rouse's Experiments		Computed from Dr. Hutton's Experiments			
		lb.	oz.	dr.						
0·0009515	0·005	0	0	1·280	1·43	1	1·63	1·11	Hardly perceptible . . .	Rouse
0·0038060	0·020	0	0	5·120	2·93	2	3·26	2·22	Just perceptible . . .	Rouse
0·0083732	0·044	0	0	11·264	4·40	3	4·84	3·30		
0·0133210	0·079	0	1	4·224	5·87	4	6·52	4·44	Gentle winds	Rouse
0·023	0·123	0	1	15·488	7·33	5	8·09	5·51		
0·025	0·130	0	2	1·280	7·55	5·14	8·33	5 67	A gentle wind	Lind
0·050	0·260	0	4	2·560	10·67	7·27	11·77	8·00	Pleasant wind	Lind
0·092	0·492	0	7	13·952	14 67	10·00	16·16	11·01	Pleasant brisk gale . . .	Rouse
0·10	0·521	0	8	5·378	15·19	10·35	16·66	11 35	Fresh breeze	Lind
0·11	1·107	1	1	11·392	22·00	15·00	24·30	16·57	Brisk gale	Rouse
0·368	1·968	1	15	7·808	29·34	20·00	32·39	22·00	Very brisk	Rouse
0·5	2·604	2	9	10·624	33·74	23·00	37·26	25·40	Brisk gale	Lind
0·585	3·075	3	1	3 200	36·67	25·00	40·51	27·62	Very brisk	Rouse
0·84	4·429	4	6	13·824	44·01	30·00	48·60	33·13	High wind	Rouse
1·0	5·208	5	3	5·248	47·73	32 54	52·70	35·93	High wind	Lind
1·146	6·027	6	0	6·912	51·34	35·00	56·69	38·65		
1·5	7·873	7	13	10·688	58·68	40·00	64·79	44 00	Very high	Rouse
1·9	9·963	9	15	6·528	66·01	45·00	72·89	49 69	Great storm	Denham
2·0	10·417	10	6	10·496	67·50	46·02	74·53	50·81	Very high	Lind
2·68	12·300	12	4	12·800	73 35	50·00	81·02	55·24	Storm or tempest . . .	Rouse
3·0	15·625	15	10	0·000	82·67	56·37	91 28	62·23	Storm	Lind
3·37	17·715	17	11	7·040	88 02	60·00	97·20	66·27	Great storm	Rouse
4·0	20·833	20	13	5·248	95·46	65·08	105·40	71·86	Great storm	Lind
4·08	21·435	21	6	15·360	96·82	66·00	106·92	74·79	Great storm . .	La Condamine
5·0	26·041	26	0	10·496	106·72	72·76	117·84	80·10	Very great storm . . .	Lind
6·0	31·490	31	7	13·440	117 36	80·00	129·69	88·54	Hurricane	Rouse
6·0	31·250	31	4	0·000	116·91	79·71	129 09	88·01	Hurricane	Lind
7·0	36·548	36	8	12·288	126·43	86·20	139·65	95·21	Great hurricane . . .	Lind
8·0	41·667	41	10	10·757	135·00	92·04	149 07	101·63	Very great hurricane .	Lind
9·0	46·875	46	14	0 000	143 11	97·57	168 11	107·80	Most violent hurricane.	Lind
9·36	49·200	49	3	3·200	146 70	100·00	162·04	110·48	Hurricane that tears up trees and throws down buildings	Rouse
10·0	52·083	52	1	5·248	150·93	102·90	166·66	113·63		
11·0	57·293	57	4	11·008	158·29	107 92	171·72	117·08		
11·12	58·450	58	7	3·200	160 00	109·00	176·55	120·37	Observed by Rochon.	
12·0	62·500	62	8	0·000	165·34	112·73	182·57	124·47		
1	2	3			4	5	6	7	8	

deduced from the height of the column of water, or it may be ascertained from the tables constructed for the purpose. Thus, according to Dr. Lind, a column of water 0·025 in. high, exerts a pressure of rather more than 2 oz. 1 dr. upon a sq. ft. of surface, and balances the effect of a gentle wind moving at the rate of about 5½ ft. in a second, or not quite 4 miles an hour. When the column of water is 1 in. high, the force of the wind on a sq. ft. is nearly 5¼ lb., its velocity 32½ miles an hour, and its character a high wind. When the column marks 3 in. the force is upwards of 15½ lb. on the sq. ft. the velocity above 56¼ miles per hour, and of the character of a storm. At 9 in. the force on the sq. ft. is stated to be 46 lb. 14 oz.; the velocity 97½ miles an hour, producing a most violent hurricane. Thus, it will be observed that in the greatest storms, the difference between the atmospheric pressures on the windward and leeward sides of any object does not amount to $\frac{1}{50}$ of the pressure of the leeward side.

From numerous experiments, Dr. Lind considered that the pressure of the wind in direct impulse is nearly proportional to the square of its *velocity*. The following Table is calculated from this, but considerably enlarged by other experiments.

Borda, however, found that the force of the wind was greater by $\frac{1}{10}$ part than Rouse's Table gives. Hutton also showed that the forces at very great velocities increased in a somewhat higher ratio than the squares of the velocity.

Henaut's Anemometer, Fig. 17, is similar in its principle and action to that of Dickinson; in the latter the impulse is received on a plain surface A, of oiled skin about 3 inches square, suspended from the top *p*, the variations of which, from the perpendicular *pbdg*, are noted on a scale *d d n*, which is marked off by direct experiments. This instrument is extremely portable, and not easily put out of order; but whilst it possesses the great value, with other instruments of this class, of not requiring any watch or other means of noting the time, it is in common with them subject to the great disadvantage of vibrating continually, especially in a rapid current, and of not recording the variation of the velocity within limits of 20 ft. per minute; it is however, very useful in steady currents of from 200 to 700 ft. per minute. The supports *g g*, are secured to a base *ct*, which is levelled by screws *rv*.

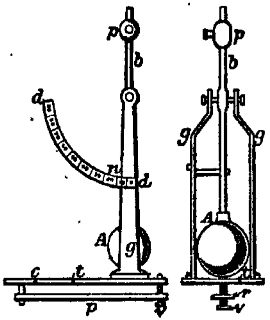


FIG. 17.

A simple anemometer that anyone can make is shown in Fig. 18: *a* is the pressure-plate, exactly 6 in. square made of galvanized iron and fastened to the pillar a 10 lb. spring balance *b*; the cylinder of the balance being fixed to the vertical tube *c*, which carries the vane, etc. To the end of the iron rod, in the balance, is attached a wire which passes over a wheel inside *c*, shown in the drawing, but, of course, in the tube, and so that the copper wire can go down centre of *c* to the weight of *d*, which must have a slit in one side to run over a wire soldered inside *f*; this keeps lower wire straight and prevents torsion. The wire is joined up in two at the bottom of *d*, and the two wires should be continued down to the bottom. The vane is of the usual form, but should form a balance for the other side, and must be weighted to form the balance necessary. The wire is continued down into the room in which dial is fixed. Here make a dial 12 in. diameter and divide it into 36 divisions each division being a full inch from the next: these divisions will indicate pounds, and if you divide the spaces between each into 5 you will have everything you require. The centre wheel has a groove, and its circumference should be exactly the length of the rod in the balance, or rather the length from 1 to 9 lb., every pound giving 4 lb on. dial. Now fix at the end a thin wire or watch-chain, the latter would be better, the old chains used in our grandfathers' verge watches—this, by the bye, must be connected to upper as well as lower wires; to the bottom one then hang a weight just sufficient to keep finger in place. Having all done, get another similar balance and fix it up against dial-plate, letting it mark 1 lb.; this will be 4 lb. on dial down below; mark this on the dial; then let upper balance be pushed on to 2 lb., mark 8 below, and so on till the whole dial is marked, then divide and mark pounds. You may go over this several times until you have carefully marked the dial, and your anemometer will be finished. (W.J.L.)

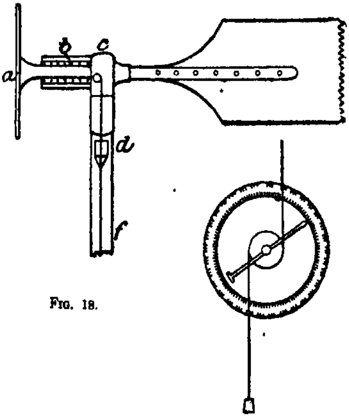
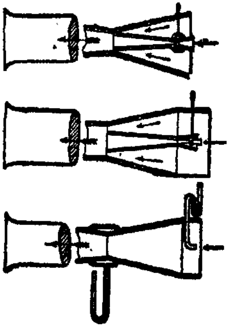


FIG. 18.

A multiplying anemometer, applicable to the measurement of the velocity of air-currents, to meteorological observations, and to the determination of waterflow, consists of a tube formed as two truncated conical tubes, the smaller ends of which are of the same area (Venturi's tubes). In this tube a much smaller one of similar construction is placed, as shown in Fig. 19. If greater delicacy be required, a third may be added, the whole system being eccentric (Fig. 20). The constricted part of the outer compound tube is surrounded by a hollow jacket, and connected with it by the small interval which separates the two truncated cones. This jacket is in connection with a U water-gauge, which indicates the velocity of the current



FIGS. 19, 20, 21.

to be measured. This arrangement for a single compound tube is shown in Fig. 21. The utility of the instrument depends upon the fact that in such a case, as shown in Fig. 21, the reading of the manometer attached to the jacket is several times that indicated by a manometer at the orifice of the tube. The former is of course negative, whilst the latter is positive. The relation between the two may be, for example, 6 : 1. In an instrument consisting of two compound tubes, and in one of three tubes, the readings were related to those at the orifice in the proportions 20 : 1 and 80 : 1 respectively. The instrument is simple, rigid, portable, and inexpensive; it affords a check on the ventilating apparatus of mines, and by a simple clockwork arrangement could be made to indicate defective ventilation; lastly, its multiplied reading conduces to great accuracy. (Atkinson and Dalgleish.)

AQUA-FORTIS.

AQUA-FORTIS is a name originally given by the alchemists, and is dilute nitric acid.

Simple or Single.—Distil 2 lb. of saltpetre and 1 lb. of copperas.

Double.—Saltpetre, 6 lb., copperas, 6 lb. in its usual crystallised state, together with 8 lb. calcined to redness.

Strong. — Copperas calcined to whiteness, and white saltpetre, of each 80 lb.; mix, and distil in an iron pot with an earthenware head.

Nitric Acid or Spirit of Nitre.—White saltpetre, 6 lb.; oil of vitriol, 1¾ lb.; distil into 1¼ pint of water.

Dilute.—Strong nitric acid 1 oz. by measure, and water 9 oz. by measure.

Compound. — Double aqua-fortis, 16 oz.; common salt, 1 dram; distil to dryness.

Nitric acid is a colourless, transparent liquid having a specific gravity of 1·52; it freezes at −55° C.; boils at 86° C.; fumes in the air, and when mixed with water evolves heat. It attacks and oxidises most metals, except gold, platinum, and some of the rarer metals. With many kinds of organic matter, strong nitric acid, if the temperature is kept down, forms what have been called nitro-substitution products, one, two, or three atoms of hydrogen being removed from the compound, and being replaced by an equal number of nitryl (NO_2). Some of these compounds are of great importance: thus from benzol C_6H_6) is formed nitro-benzol ($C_6H_5(NO_2)$ used in the manufacture of aniline. With phenol or carbolic acid (C_6H_6O) is formed tri-nitro-phenol or picric acid ($C_6H_3(NO_2)_3O$). From cellulose, which is cotton or similar fibre ($C_6H_{10}O_5$) is obtained tri-nitro-cellulose $C_6H_7(NO_2)_3O$) or gun-cotton.

AQUA-REGIA.

THIS is a mixture of nitric and hydrochloric acids. (Nitric acid is sometimes called spirit of nitre, while hydrochloric acid is often called muriatic acid, or spirits of salts.) The name Aqua-Regia was given by the alchemists owing to the power this mixture has of dissolving gold, platinum, etc., which neither of the two acids named will do separately.

(*a*) Distil together 16 oz. of nitric acid with 4 oz. common salt.

(*b*) Mix together equal parts of nitric acid and hydrochloric acid.

(*c*) Nitric acid 1 part, and hydrochloric 2 parts.

Of the above (*c*) is most effective.

AQUARIUM. REPAIRING LEAKS.

LEAKINESS is a fault inseparable from all wood-built aquaria. If you remove the zinc covering the bottom, you will find water underneath, which slowly percolates, and very often travels along until it meets the groove in which the glass is set, where it make its unwelcome appearance. I doubt very much if it be possible to build a permanently tight aquarium if the same is framed in wood. By chance one might succeed. The wooden bottom contracts, and opens some minute joint in the cement. Under the pressure of the water the moisture creeps in, and the wood then swells, opening wider the cracks. Then there is another fertile source of leakage, due to the water pressure forcing the glass sides outwards, and causing the cement to separate. The oftener the aquarium is emptied the worse the fault grows, and it is almost incurable. What is wanted for wood-framed aquaria is an elastic cement (marine glue useless), and it has to be found yet. I think the best all-round cement consists of equal bulks of litharge and pulverised rosin—no sand—mixed into a thin paste with boiled linseed oil and applied at once. To make the flat bottom watertight, marine glue of good quality may be used in this instance. When the wood is quite dry saturate it with a thin solution of the glue, afterwards breaking up the glue into small pieces, sprinkling them thickly over the bottom, and ironing out with a hot iron. While still soft, completely cover with a layer of small gravel (shore), and press into the glue with the iron. A dusting of sand will complete the job. Of course, dig out all the cement in the glass grooves, and fill them again with the composition given above. The depth of the grooves should be twice the thickness of the glass, assuming ¼ in. plate to have been used, and the width the same. The groove is part-filled with the cement, the glass slid in, and pressed outwardly by small blocks of hard wood pushed in the grooves. This prevents springing of the glass when the level of the water is at any time reduced. Fill the inner groove level with the aquarium floor, and if the job has been properly done very little water will find its way through. Undoubtedly all aquaria should be built entirely of slate, and though in saying so I advocate what I have never practised, all my large 80-gall. sea-water tanks being built of baywood, I am fully alive to the fact that I might have saved myself much trouble. Slate aquaria are, of course, much more costly, to begin with, than those constructed of wood, and economy is very frequently a determinative factor in the case. Use the dryest baywood obtainable, make the bottom two-ply, crossing the grain, and screw together with brass screws. But this concerns the building of aquaria, and not the stopping of leaks. ('English Mechanic.')

* * *

BAKING POWDERS.

THE following is condensed from a lecture on the chemistry of confectioners' materials, delivered by William Jago, before the Society of Arts.

Ammonium Carbonate. — Among the first of aerating agents is the solid commercial ammonium-carbonate, called by the confectioner, "ammonia" or "volatile." This salt may be represented by the formula $2(NH_4)\ 2\ CO_3 \cdot CO_2$ and is a mixture of the carbonate and *carbamate* of ammonium. The compound has an ammoniacal smell and an acrid burning taste. On the application of heat, "volatile" is decomposed into gaseous ammonia, water, and carbon-dioxide gas. The commercial salt should be almost free from non-volatile bodies, and good specimens will leave only a trace of fixed foreign matter after being subjected to a temperature of 100° C., the actual quantity being from 0·04 to 0·4 per cent. As the composition of the salt varies, its strength may be determined by an estimation of the alkalinity, titrating with sulphuric acid, and using methyl-orange as an indicator. The salt is continuously losing ammonia, and so becomes weaker. Commercial samples vary in strength from an alkalinity equivalent to about 80 to one of about 93 per cent. of the pure salt. If ammonium carbonate be mixed with the other constituents of a dough, there is very little change until the goods are placed in the oven. With a rising temperature, the liberated carbon-dioxide and ammonia gases distend the mass and so produce the desired lightness. When withdrawn from the oven such goods may smell and taste most strongly of the ammonia. With small articles of a porous texture, this smell soon completely passes off, but with larger ones this does not occur at all so readily, and for this reason "volatile" has to be used sparingly and cautiously by the confectioner, and has practically passed out of use in preparations sold for domestic use.

Sodium Bicarbonate is another salt capable of giving off gas, under the action of heat alone. This compound $NaHCO_3$, then becomes the normal carbonate, Na_2CO_3, with the evolution of steam and carbon dioxide. A temperature of 38° C. (100° F.) is sufficient to complete this change. Sodium bicarbonate has only a slight brackish flavour, but the normal carbonate has a strong alkaline taste. For this reason, and because only half its gas is evolved by heat, the bicarbonate is but seldom used alone. The objectionable flavour is, however, the much more pressing reason of the two, because a double quantity of the carbonate would cost much less than the [illegible] of acid necessary to act on the one portion of carbonate only. Commercial bicarbonate of soda is obtained of a high degree of purity, and usually gives an alkalinity very nearly equivalent to 100 per cent. of the pure salt. At times figures are obtained which even go beyond this, and one is confronted with, perhaps, apparently 103 per cent. In such cases the explanation lies in the fact that the salt contains more or less sodium carbonate as impurity. In the analysis of the bicarbonate it is always well to search for, and estimate approximately if necessary, the quantity of normal carbonate present. In using bicarbonate great care must be taken that the salt is finely ground and intimately mixed with the flour and other constituents of the dough. Neglect of such precautions leads to the formation of small masses of the normal carbonate during baking, and these in turn act on the proteid constituents of flour with the production of a yellow stain or spot. Further, flour thus acted upon by normal carbonate evolves an unpleasant soapy odour. Like ammonium carbonate, the bicarbonate of soda only commences to evolve gas when subjected to the heat of the oven.

Tartaric Acid.—When sodium bicarbonate is treated with an acid, the whole of the carbon-dioxide gas is evolved, and the corresponding salt formed. Of all acids, that found most convenient by the confectioner is tartaric acid, either in the free state or as its acid potassium salt. Tartaric acid is widely distributed in nature, and is manufactured from some of its compounds occurring in grape juice. The acid occurs in commerce as a fine white powder, having a clean acid flavour, and is very soluble in water. When tartaric acid and sodium bicarbonate are mixed in with flour in equivalent quantities, the result, by moistening with water, is, that the acid attacks the carbonate, liberating all its carbon-dioxide, and forming normal sodium tartrate. This latter salt is comparatively tasteless, and the presence of the quantity produced as a residue from the amount of acid and soda necessary for the aëration of an average dough is not sufficient to injuriously affect the flavour of the resultant goods. The action of tartaric acid and the bicarbonate, or more shortly "soda," commences immediately on the addition of water, and, for that reason, it is well to get the dough into the oven as speedily as possible. Then, with the greater heat, solution of the two re-agents and their consequent mutual action, go on with augmented speed. Tartaric acid being somewhat expensive, it is important that no waste of it should occur, and as all, mixed in a dough, that is in excess of the equivalent of the soda is lost, it is well to remember that the proper proportion is 15 parts by weight of tartaric acid to 17 parts of soda. Tartaric acid should, on analysis, show an acidity equal to 99 (or upwards) per cent. of pure acid, and the ash should not exceed 0·25 per cent. Tartaric acid is said to have been adulterated with alum and acid potassium sulphate; but both these would be detected by an abnormally large percentage of ash, and also by the presence of sulphates.

Cream of Tartar.—Not only is tartaric acid itself employed, but so also is its acid potassium salt, cream of tartar. Cream of tartar exists in the crust or tartar deposited by wines on keeping, and is obtained by a process of solution, purification, and re-crystallisation. The salt occurs commercially as a white powder, and differs from tartaric acid in that it is only very slightly soluble in cold water, one part of the salt dissolving in about 250 of water at 50° F., whereas boiling water dissolves it in the proportion of one part of "cream" in 15 parts of water. To the confectioner, this is a most important property, because as a result a mixture of cream of tartar and bicarbonate of soda, as an aërating agent, is almost inactive in the cold. Doughs made with this mixture, undergo little or no aërating change until placed in the oven. Then the rise in temperature results in solution of the cream, and its consequent action on the bicarbonate. This salt therefore becomes active just at the time when such activity is most effective. The salt resulting from the action of these two re-agents on each other, is well known under the name of "Rochelle salt." It possesses only a bland saline taste, and hence does not sensibly affect the flavour of goods in the manufacture of which "soda and cream" are employed.

Sulphates and Phosphates.—Tartaric acid has been mentioned as the one of most importance to the confectioner. Among more or less successful substitutes are acid potassium sulphate, acid calcium and potassium phosphates, and phosphoric acid. The three former are obtainable as white powders, and, mixed with starch in various proportions, are used as substitutes for tartaric acid and cream of tartar respectively. In older confectioners' recipes alum is sometimes included as an ingredient; this body has a powerful acid reaction, and with soda can be used as an aërating agent. In view of the injurious nature of alum, its employment need only be mentioned in order to condemn it, and to point out that some non-injurious form of acid should be used in its stead.

Following are recipes for compounding baking-powders:—

(1) Tartaric acid powder	8 oz.
Bicarbonate soda	9 „
Rice flour	10 „

A teaspoonful to every 1 lb. flour.

(2) Tartaric acid	8 oz.
Carbonate of soda	8 „
Arrowroot	8 „

(3) Bicarbonate soda	16 oz.
Tartaric acid	14 „
Carbonate magnesia	6 „
Farina	12 „

Rub through a sieve.

(4) Dry carbonate soda	8 oz.
Dry tartaric acid	6 „
Carbonate magnesia	2 „
Turmeric powder	1 „

The soda and acid are properly dried

before mixing, or the powder spoils by keeping. Preserve in stoppered bottles.

(5)		
Tartaric acid . .	5	oz
Cream of tartar .	15	,,
Carbonate of soda .	20	,,
Rice powder . .	40	,,

(6) Borwick's German is an artificial fermentation powder, compounded with coarse maize flour.

(7) Goodall's is a compound of:—

Rice flour	2 parts.
A mixture of tartaric acid and bicarbonate of soda (each)	1 part.

(8) Horsford's. This is a powder supplied in two packets. The one contains an acid phosphate of lime and magnesia, made up with a certain quantity of flour, and the other is bicarbonate of soda, with a little chloride of potassium.

(9) Tartaric acid ½ lb.; bicarbonate of soda and potato farina or British arrowroot (of each in powder) ¾ lb. Separately dry them perfectly by a very gentle heat, then mix in a dry room, pass the mixture through a sieve, and at once put it into packets, observing to press it hard, and to cover it with tin-foil or close-made paper, to preserve it as much as possible from the air and moisture.

(10) Green's.

Tartaric acid	35 lb.
Sesquicarbonate of soda .	56 ,,
Potato flour	1 cwt.

Mix as before.

For use, 1 or 2 teaspoonfuls of baking-powder are mixed with the dry flour, and other ingredients, which are then made into a dough, as quickly as possible, with cold water, and at once baked or boiled. By the addition of about ½ dr. of turmeric powder to each 1 lb. of the mixture it is converted into egg-powder. It should be preserved in bottles or tins, so as to prevent the absorption of moisture.

(11)	
Tartaric acid . . .	½ lb.
Bicarbonate of soda	12 oz.
Starch	12 ,,

Dry each thoroughly previous to admixture, which is effected by passing through a fine sieve repeatedly; pack the powder down tightly, to prevent the absorption of moisture.

(12)	
Bicarbonate of soda	4 oz.
Tartaric acid . .	3 ,,
Farina	16 ,,

Mix all together. By farina is meant any cheap farinaceous material—wheat, rice, or sago flours, etc. To make the packets requires a piece of wood, say 6 in. long, for small packets, and the exact size in thickness and width that the packet is to be. The end of this piece should fit into a block of wood and go through it. Take the paper and fold it on the end of the stick, and close it at the end so as to make a square bag; now put the stick with the paper on it into the block, and withdraw the stick, leaving the paper in the block. It is more convenient to measure the powder than to weigh it. Put the powder in a small tin-plate funnel, and shake it into the paper; remove the funnel, and fold down the other end of the paper, flatten the folds with the end of the square stick and push the packet out of the block. The whole operation of making the packet should take a very short time.

(13) *Royal.*—A sample contained the following approximate proportions.

Granular tartaric acid .	12 oz.
Granular bicarbonate of soda	6¼ ,,
Starch	12 ,,

(14) *Rumford's.*—(Approximate.)

Bicarbonate of soda .	7 oz.
Phosphate	14½ ,,
Starch	3½ ,,

(15)	
Cream of tartar . .	12 oz.
Bicarbonate of soda. .	5 ,,
Starch	2 ,,

* * *

BALL VALVES, NOISY.

DOUBTLESS every practical man has experienced more or less trouble from this cause, and in some cases quite frequently. It is not at all a rare complaint, but it is one generally of a very annoying nature to all who may be residing in the house where the valve is.

There are two kinds of sounds, due to two quite different causes. One is a deep humming; the other a jarring or jumping noise like successive shocks more or less quickly repeated. Both are only noticeable when the valves are partially or nearly closed. A full-open valve seldom makes a noise of a disagreeable character. If it does it had best be changed for another.

The humming noise is heard with valves on a high pressure service as a rule. As the valve closes and the passage through it becomes more restricted, the strain exerted by the water and consequent friction causes the noise to occur. We may well liken the effect, if not the cause, to what takes place in a steam-horn or whistle. The steam is arranged to pass into and through a restricted but suitably shaped outlet aperture, and a very distinct noise is the result, if the pressure is sufficient. The volume of steam and the pressure have to be in some exact ratio with the area of the outlet aperture, and this is so with the ball-valve when it is closed sufficiently. If the ball-valve aperture could be kept fully open until the moment of closing, no noise of the kind could occur, as the proportions of the outlet, with the volume and pressure of the water, would be wrong, the former being of too great an area to the latter for the production of sound vibrations.

The measures that can be adopted to prevent this humming noise are, therefore, two. One is to put a larger ball-valve, or a valve with a more roomy way through it. The other is to reduce the pressure and the volume of water coming to the valve. The latter is best and oftentimes the easiest. The method of doing it is to choke the service close behind the valve, practically reducing the bore of the service-pipe. This might be effected by pinching the pipe, if it is lead, or by taking the valve off and putting a piece of small tube or a nipple-piece in the boss or tube which the valve is screwed into. Another way is to solder a piece of sheet metal over the tail aperture of the valve—the tail being the part that screws into the boss or pipe—then boring a $\frac{1}{8}$ in. or $\frac{3}{16}$ in. hole in it. Still another way is to insert a stop-cock just behind the valve. This could be closed to any desired extent to check the volume and the pressure of water. The results will be identical with checking the service tube to a steam-whistle: plenty of steam may come through, but the sound will be wanting. Checking the service pipe to the ball-valve cannot do any harm or cause any inconvenience. There will still be abundance of water come through for all ordinary purposes.

The other noise that occurs with ball-valves, and which is more or less a chattering kind of disturbance, is caused by the movement of the water in the cistern. As water enters the cistern, falling into it with some force, that which is already there becomes agitated, and assumes the character of little irregular waves on the top. When the cistern is sufficiently full to begin lifting the ball of the ball-valve to close it, the ball is not lifted in a slow and regular manner, but is caused to move up and down on the disturbed water. When the valve is about half, or a little more than half closed, the ball when lifted by the disturbed water wholly closes the valve, but only to open again and then close as fast as the agitated water moves it. If the water coming in is served at a fair pressure there will be a distinct noise and shock every time the valve is thus opened and then abruptly closed. This is a noise, which makes itself heard throughout the house, and in point of their irritating qualities there is little to choose between the two. Where there is an intermittent water supply the trouble only occurs once a day, but with a constant supply it may occur every time the tap is opened. The remedy for this latter cause of noise and annoyance is to prevent the agitation of the water in the cistern by that flowing in. This is simply effected by fixing a tube to the nose or outlet of the ball-valve so that the water it discharges does not fall on to the water already delivered, but delivers it below the water level. A piece of rubber tube fixed to the nose of the valve and allowed to drop about half-way down the cistern will do; or a piece of metal tube can be soldered on. If the inflowing water enters beneath the level of the water already there, it will not agitate it, or cause the valve-ball to dance up and down. ('English Mechanic.')

BAMBOO WORK.

(*See also* BASKET WORK.)

BAMBOO is known as an "Endogen," each new layer of wood being formed within the old layer and not outside it, consequently the outside is the oldest and hardest.

Those who work in bamboo regularly may have noticed that it is liable to split at the ends, if not cared for, a split sometimes working up the whole length if not attended to. This is usually the result of stocking the bamboo carelessly, and not protecting the ends. The best plan for keeping a stock of bamboo is by erecting upright wooden partitions say 4 ft. 8 in. high, by 2 ft. 9 in. wide, along the floor of the workshop, spacing the partitions such a distance apart as to take the different lengths of bamboo. By this plan the ends are not left unprotected. Further protection can be afforded by making light wood frames covered with roofing felt to rest on top of the partitioned spaces, the felt being cut larger than the frame one way so as to hang down a little way in front of the racks. On no account ever make bamboo racks nearer the ceiling than can be avoided, as the heated and dry air is injurious to the material.

The principal arts in bamboo-work are jointing and bending, and the former is the chief of these two. In fitting two pieces at right angles, as Fig. 22, first with a half-round fine rasp or coarse file hollow out the end of *a* to come neatly against *b*, then fit a straight grained piece of wood tightly into *a*, as Fig. 23, and with a brace and bit bore a hole in *b*, to take this plug or dowel *tightly*. Have some hot glue ready, remove the dowel from *a*, and after gluing it, drive it tightly home into the hole in *b*. Now glue the exposed end and put *a* on to it and tap home gently with a hammer. Remember that for lasting work there are at least two essentials, viz., tightly fitting dowels and hot glue. It is also the best plan to always glue both surfaces that are to come together, not letting a glued surface come against a dry surface. Thus the dowel has glue put on it, but, in addition, the bamboo should be glued where the dowel is to touch. Some consider this as essential as anything in good gluing. Should *a* be of thinner stuff than *b*, it can be glued direct into a hole in *b* without a dowel, but as glue does not hold well on a hard

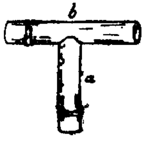


FIG. 22

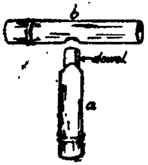


FIG. 23.

polished surface, the end of *a* would then have to be roughened with a file to take the glue properly.

To make a joint at an angle such as Fig. 24, the same plan is resorted to as with Fig. 19, but as it is difficult to make a clean good-fitting hole in *b* at an angle to receive the dowel in *a* properly, it is usual to strengthen this joint by a screw passed through after the joint is glued and dry.

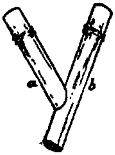


FIG 24.

To make a joint at right angles as Fig. 25, first saw, then rasp the ends to make an accurate mitre, and then make an angle dowel with the grain in the wood as Fig. 26, and glue this in soundly. A cheaper, that is quicker, way, is to first plug the two ends of the rods soundly, then saw and rasp the mitre, and glue together like the angles of a picture-frame. This by itself, however, is not strong enough for bamboo, and a screw must be used to strengthen and keep the joint secure.

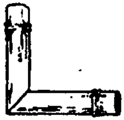


FIG. 25.

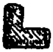


FIG. 26.

Where a cross joint has to be made, as Fig. 27, the dowel after being carefully fitted to the two ends is soundly glued into the middle piece, as shown, the ends being glued on afterwards.

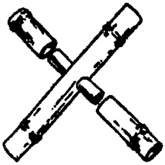


FIG. 27.

To bend bamboo, drive a large staple into a bench and, then bend it down flat, as Fig. 28, so that its loop projects beyond the bench, as shown. This is all that is necessary except an atmospheric or Bunsen gas-burner, or methylated spirit lamp, with which to heat the bamboo. Do not apply the heat to one precise spot but heat about 6 in. or 8 in., then gradually bend it by pressure on the projecting end. Always bend between knots, but if the bend must come where a knot is, then notch the knot with a saw-cut on the side that will be inside the bend. Bend gradually, heating and cooling more than once if much of a bend is wanted. In cooling, keep the pressure on the projecting end, then cool with a rather wet cloth or sponge.

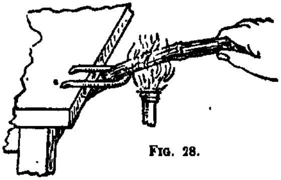


FIG. 28.

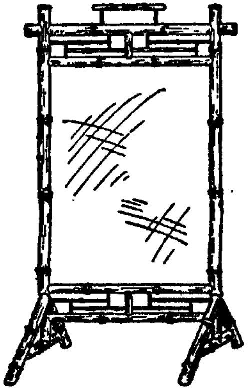


FIG. 29.

Bamboo-work is made up in flat sections, these being allowed to dry and become hard before they are joined up to make the whole article. When joining up, the whole can, in most cases, be "cramped" up by winding two or three thicknesses of stout string round, and should the string be difficult to get tight, pass a stick under one of the strings and twist it round until the required pressure is obtained. As an example of bamboo-work, Fig. 29 is given, this being a fire-screen of neat appearance. The centre can be filled in with whatever material may be preferred.

* * *

BAROMETERS
AND WEATHER-GLASSES.

A BAROMETER is an instrument by which the weight (sometimes termed pressure) of the atmosphere is measured or indicated, and as the air we breathe has a constantly varying weight, and the weight varies to a marked degree with variations in the weather, the instrument has gained its name of weather-glass. The instrument is very simple in parts, being merely a glass tube filled with mercury, the column of mercury being held up by atmospheric pressure, this pressure being equal to, and capable of holding up, a column of water about 32 ft. high, or a column of mercury 30 in. high, these measurements varying with the altitude and with the state of the atmosphere.

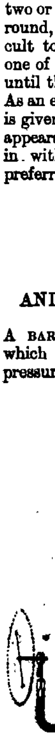


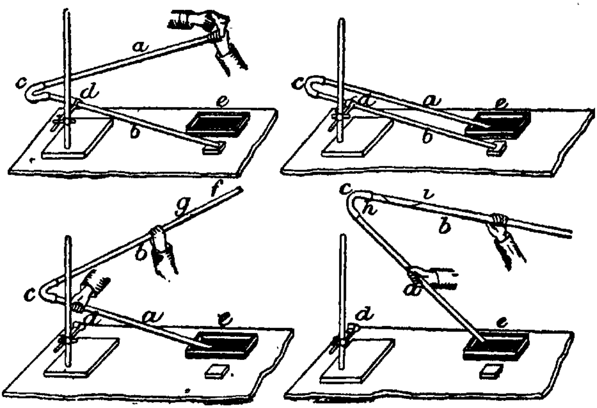
FIG. 30.

An ordinary form of weather-glass has working parts more or less resembling Fig. 30, these consisting of a tube turned up at its lower end, this lower end being open with a float in it, the upper end being closed. The float has connected a cord which, passing over a wheel, is balanced by a small weight. The tube is filled with mercury, and, as only one end of the tube is open, the mercury cannot run out owing to the pressure of the atmosphere upon this open end, yet the level of the mercury must vary with every variation in the density or weight (pressure) of the air as it occurs. With the balanced float, operating a wheel as shown, each variation is indicated by the visible pointer on the front of the dial.

(1) To make a cheap barometer. Obtain a straight fine glass tube, about 33 in. long, and with a clean interior, sealed at one end, and having an even uniform bore of about 2¼ lines diameter. The mercury to be used should be perfectly pure, and free from all air and moisture. This latter requisite may be assured by heating the mercury in a porcelain dish to nearly the boiling point, previous to using it. The tube is then held securely, with the open end uppermost, and carefully filled with the liquid metal. The imprisoned air is removed by shaking. The open end of the tube is then securely covered with the finger, the tube is inverted, and the end covered by a finger is plunged below the surface of a little mercury placed in a small vessel to receive it. The finger is then removed, when the mercury in the tube will immediately fall to a level of about 30 in. above the surface of that in the small reservoir below. The tube is again closed by pressing the fingers on to the open end, brought to a horizontal position and gently shaken for a short time. After a portion of the air embedded in the mercury has entered the vacuum, the tube is transferred to the trough, manipulated as before, and the operation is repeated two or three times until the mercury is freed from the adhering air. A simple method of ascertaining the quantity of mercury required is to fill the tube

with water from a weighed measure, weigh the measure again, when the loss of weight multiplied by 13·5 will give the weight of mercury required. In order to attach the scale correctly, it will be necessary to compare the indications with those of some good instrument.

(2) **Bogen's Method.**—When the section of tubing is reduced to that of a capillary tube, the filling with mercury by the foregoing method is impracticable; this difficulty is overcome by the following modification.



FIGS. 31, 32, 33, 34.

Having filled the barometer tube with mercury, clamp it to a stand in the position shown in Fig. 31, and connect it by a 3-inch piece of rubber tubing (*c*) to a glass tube (*a*) of the same diameter and length, but open at both ends. Hold the open tube as shown in Fig. 31, and fill it with mercury through a small funnel. Lightly tap the rubber tubing to free any air bubbles that may have collected there, then, while the open end of the tube (*a*) is partially covered by the finger, press the rubber until a small portion of the mercury has been forced out; complete the closing of the tube with the finger, and immerse the closed end in the dish of mercury (*e*).

On withdrawing the finger from the orifice the tubes will be in the position shown in Fig. 32, and both quite filled with mercury.

The vacuum is formed as follows: Release the tube (*b*) from the clamp and raise it with one hand to a nearly vertical position, meanwhile holding the tube (*a*) firmly with the other hand. A vacuum (*g f*) (see Fig. 33) will then be formed in the tube (*b*) into which any air embedded in the mercury will be released; then gently lower tube (*b*) while tube (*a*) is raised, until they are in the positions shown in Fig. 34, when the air will be in the position "*h i*." The operation is then reversed, and repeated two or three times, until all the air is withdrawn from the mercury, which will be shown by its giving a characteristic metallic sound, when the barometer tube is gently shaken endways.

The method is applicable to siphon

and cistern barometers, and can also be used for the exhaustion of capillary tubing; the employment of an air pump and application of heat in exhausting the latter will greatly accelerate the operation. The manipulations which the method requires are simple, though great caution must be exercised in handling the glass tubes, when filled with mercury, to avoid breakage of the glass; they can be performed with good results by persons unaccustomed to experimental work, always giving an excellent vacuum.

(3) **Filling Tubes.**—Application of Wright's apparatus for distilling, to the filling of barometer tubes. In Fig. 35, *a* is a vessel full of impure mercury; *b* a tube about 30 in. long; *c* an enlargement of *b*; *d* and *e* tubes inclined in opposite directions; *f* an arm for connecting with a Sprengel pump; *g* a tube a little over 30 in. long; *h* a reservoir with an outlet to the air; *h* is filled with pure mercury. The air is now exhausted through *f*; the mercury rises in *b* and *g* until *c* is partially filled; a Bunsen burner is placed under *c*, and the mercury distils over into *g*, and flows out through *h*.

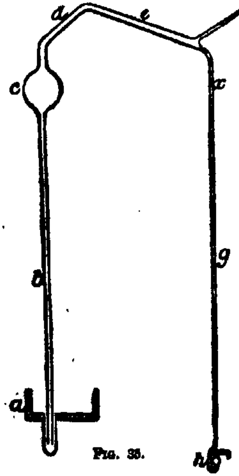


FIG. 35.

If now *g* is cut off at *x* a few inches below the junction of *e* with the arm *f* (the part *h* being no longer used), and a glass cock be inserted at *x*, then by means of a short rubber tube this cock can be connected with the open end of the barometer tube to be filled, which latter will take the general position of the whole tube *g*.

The rubber tube must be covered with melted sealing wax. The impure mercury in *a* should first be washed in acids and dried before introduction. At the beginning of operations, *a* is full of impure mercury, but the rest of the apparatus contains only air. The Sprengel pump is set in motion and gradually exhausts the air from *b*, *c*, *d*, *e*, and the barometer tube, until no air bubbles can be seen in the running mercury of the Sprengel pump, and until the sharp click is heard when the drops of mercury fall. The tube *f* is then sealed or a stop cock in it is turned, cutting off the Sprengel pump; the Bunsen burner under *c* is lighted, and the mercury will distil over into the barometer tube, which will thus be filled without allowing the mercury to come into direct contact with the air.

The barometer tube should be constantly watched in order to detect any air bubbles that may be carried over; when seen they must be cooked out by heating the tube slightly by means of a Bunsen burner. When the barometer tube has become filled with the mercury, the cock at *x* can be closed, the sealing wax is broken and the tube is replaced by another. (F. Walde.)

(4) See (4) and (5) as to whether the mercury be suitable. If the barometer has a Fitzroy pattern tube with its lower end turned up thus J, first fill this end with mercury then press your thumb or hand over the opening, tilt the tube over and coax the mercury round the bend into the main tube. Repeat this until the tube is quite full, then care-

fully invert the tube to its proper upright position. When this is done the mercury will be seen to descend for a little way at top, then stop at its right position. In doing this some mercury will overflow at the open end of the J at bottom, and, in anticipation of this, it should be held over a plate or pan. If the tube is a straight one, having its lower end open and dipping in a small cup or reservoir of mercury, then the filling can usually be done through a fine metal or paper funnel, the tube being inverted, i.e. with its open end upwards, while this is done. When it is full, a finger is pressed over the open end and kept there while the tube is inverted again and its open end put beneath the mercury in the cup or reservoir. In this case also the tube must be quite filled with mercury, and, when the finger is removed from the open end (in the cup of mercury) the mercury in the tube will fall a little way as already explained. When a tube, of either kind, is filled with mercury, and before it is turned its proper way up, it is a good plan to heat its lower closed end, as by doing this air is expelled from the mercury, but great care must be used, as the heating in unskilled hands is so liable to result in fracture, a broken tube, and possibly loss of mercury. Letting the filled tube, with closed end downwards, stand in a warm position (over a stove when the fire is just out at night) for a few hours is almost as good as heating the mercury.

(5) Cleaning Barometer Tubes. To clean the tube of a film, etc., get a piece of covered electric bell wire and fix on the end of it a piece of wash-leather. It must be very fine wash-leather, cut into narrow strips; wrap the wire from end to end, leaving a thicker piece at the end to tightly fit the tube.

Clean with warm water, soda, and soap-powder, afterwards with cold water, using the covered wire all the time, of course replacing the wet with dry leather to finish. If the wire is not covered, the tube will most assuredly break, if not at the time, certainly within 48 hours after using the wire. Clean the mercury with nitric acid and water, say, for 4-5 lb. of mercury, 4 teaspoonfuls of acid and 20 teaspoonfuls of water; put the whole into a soup plate, and put it in the oven or before the fire, and heat up to about 140°-150° F., stirring it at intervals until the acid forms a sort of powder or refuse on the top of the mercury. When cold, run the mercury through a fine paper cone a few times, and then it is fit for use.

(6) Siphon Barometer.—A few words must first be said regarding the selection of the glass tube, as on its fitness for the purpose the instrument's future excellence will very much depend. Ordinary white, easily fusible glass tube should not be used, as the mercury is apt to attract its oxide of lead, and not only become impure, but by adhesion to the inside of the bore hinder the free oscillation of the barometric column. The proper kind of tubing is that which shows a greenish tinge in the glass when looked at endways. For either of the instruments shown in Fig. 36 or 37, it should not be less than ⅜ in. outside diameter and ¼ in. bore; and if slightly larger may still be used with advantage.

For the siphon barometer, Fig. 36, a piece of tube about 38 in. long is required. This is to be well cleaned by running through it plenty of warm soft water, while at the same time a little swab made from a piece of soft, fine linen, tied in the middle of a cord, is pulled through the bore from end to end. After the water has drained out, alcohol in which precipitated chalk is suspended, should be applied to the inside by means of the swab. A clean swab moistened with alcohol will remove the particles of chalk, when, the cord being withdrawn, fresh alcohol is to be poured through, after which the tube must stand in an upright position till it has drained perfectly dry, a little cap of paper meantime, being placed on its upper

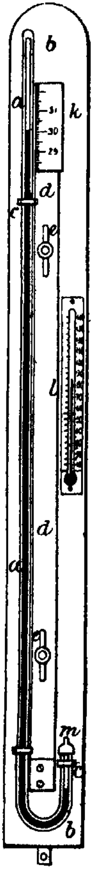


FIG. 36.

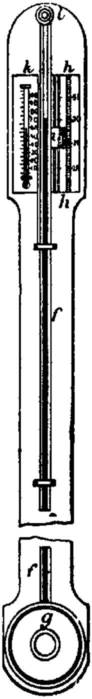


FIG. 37.

end to exclude dust. The inner surface of the tube must finally be polished with a small piece of soft washleather fixed on the end of a clean, smooth, *covered* wire.

The tube thus cleaned and dried is now to be closed at one end by drawing it apart in a gas flame about 2 in. from the extremity. The narrow pointed end, which forms when the tube is drawn asunder should be pressed and rotated in the flame till a substantial and well-rounded closing has been obtained. About 32 in. from the sealed extremity a U-shaped bend is to be made. Care must be taken to make the curve a gradual one, as failure in this respect would not only mar the appearance of the instrument, but might also tend to narrow the bore and make the bend a weak point. The arc of the curve is to be 1¼ in. The longer limb of the siphon is thus 32 in. long and a shorter one about 3 in. The short limb is not to be bent down quite parallel with the longer one, but should make a slight angle with it to render the subsequent introduction of the mercury more easy. The tube *a* is to have adapted to it a supporting stand *b*, which may be a piece of dressed walnut, 34 in. long, 3½ in. wide, and about ⅝ in. thick, rounded off at the top, and furnished with a brass screw and ring for hanging up. A shallow groove, curved to correspond with the bent tube, is made on the wood. The three small brass clasps *c*, provided for attaching the tube to its support, may be readily cut from sheet-brass, polished, bent to shape, and drilled with a hole in each end to receive the appropriate small brass screws. The sliding scale support *d* is a slip of cherry or mahogany, 1 in. wide, $\frac{3}{16}$ in. thick, and 28 in. long, having two longitudinal cuts *e*, made therein, through which pass two screws which fasten it to the walnut scale and allow of its motion upward and downwards These screws may be of brass with milled heads, or a cheap and excellent substitute may be found in the brass buttons with screw-stems sold for fastening carriage aprons. These are to have their stems passed through the longitudinal cuts *e*, and screwed into appropriate holes in the walnut support till their projecting shoulders bind on the scale support and prevent it from moving, except when required. The bottom of the sliding scale support is a piece of sheet-brass cut square and attached by two small rivets or screws. Its angle or corner is used as an index, as will afterward be explained. A scale *k* made of a piece of ivory veneer, 4 in. long, and about 1¼ in. wide, is required for the upper end of the sliding support. This must be carefully and accurately divided into inches and tenths, the lowest inch mark being numbered "29," the next "30," and the upper one "31." It will be well to have the figures and lines done by an engraver; but, if economy be a consideration, the markings can be very well ruled with a fine pen, and after the ink has dried a coat of thin dammar varnish will protect the lines from injury by moisture. The ivory scale is now to be fixed to the sliding support with the upper end of which its top exactly corresponds. If the measures have been correctly made, its 30-in. mark will now be situated exactly 30 in. from the bottom of the brass index. An excellent cement for attaching the ivory to the wood is made of a little isinglass dissolved by heat in equal parts of alcohol and water. The walnut support *b* should receive two or three coats of copal varnish. The cherry wood slide *d* may either be finished with boiled linseed oil or varnish, according to fancy.

All parts of the instrument being thus fitted, it only remains to introduce the mercury. For this purpose the tube *a* being detached from the support, is placed upon a level table and sustained by small pieces of wire, so that the short limb is uppermost, the long limb lying flat upon the table. The mercury used should be as pure as possible: though if freshly distilled mercury cannot be had that of commerce may be used, provided it has not become contaminated by lead or kindred metals. A fair test of the goodness of mercury is made by dropping a little into a clean white plate and causing it to run about. If bright round globules are formed, which readily coalesce and leave no trails of discoloration on the china, the metal is sufficiently pure. If, however, the drops become pear-shaped and soil the plate with dull, metallic splotches, the metal must be rejected. Before being used for filling, the mercury should in any case be forced through small pinholes in a piece of thin chamois skin to remove mechanical impurities. The tube being filled, is next raised gently into a vertical position, with its closed end uppermost. The mercury will descend a few inches, showing the Torricellian vacuum in the upper part of the longer limb, while at the same time it rises and overflows from the open orifice of the short limb. From the latter, enough of it should be displaced, by inserting a small round piece of wood into the bore, to leave a couple of inches empty. After this it only remains to finish the instrument by attaching the tube *a* to its support with the brass clasps *c* and screws. A narrow strip of green surface paper, 4–5 in. long, slipped behind the upper part of the tube where the vacuum appears, is an improvement to the look of the instrument and an assistance when taking the readings. It will now be evident at a glance that by bringing the lower brass corner of the index level with the surface of the mercury in the short limb, as often as an observation is to be made, the height of the mercurial column in inches and decimals will at once be shown on the ivory scale.

A small thermometer *l* fixed beside the sliding scale is at once a useful and ornamental addition to the barometer. A small cap *m* of metal or wood must be loosely fitted over the open end of the tube to exclude dust. (A. F. Miller.)

(7) **Cistern Barometer.**—The tube must be cleaned as already described, and closed at one end; but in-

stead of being bent it is left straight, and cut off at a length of 32 in. Fig. 38 shows a section of the cistern, which is simply a small wooden cup turned neatly out of hard wood; its outside dimensions being 1¼ in. diameter and 2¼ in. high, and the inside cavity being 1⅛ in. diameter and 2 in. deep. A cut made with a fine saw along the line *a* separates the underneath part of the cistern as a small wooden ring, to the bottom of which must be glued a piece of stout wash-leather *b*, made loosely convex so as to bulge readily inward and outward, forming the cistern-bottom and supplying a movable surface on which the atmospheric pressure is to act. A hole *c* in the closed top admits the pipe *d*, which passes down into the cistern till its end is level with the line of division *a*, and is secured in place by being cemented where it goes through the wood of the top. A small hole *e* for adjusting the height of the mercury is made ¼ in. below the closed top of the cistern, and stopped for the time with a little wooden plug.

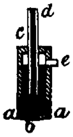


FIG. 38.

The filling with pure mercury is to be done as already described in the case of the siphon, except that the tube may now be placed in a nearly vertical position with its closed end downward; a small straight funnel is to be used for pouring through. The cistern has also to receive as much mercury as will fill it to the edge *a*, after which the ring-shaped piece, bearing the wash-leather bottom *b* is coated with glue on its sawn surface and pressed on in place, so closing the cistern. As soon as the glued joint is firm, the tube may be turned up into proper position by placing the finger on the washleather bottom, and pressing it inward till the orifice of the tube is felt, when the whole is quickly inverted. Thus no air enters the tube during the moment of turning over; and as an instant later its opening is covered by the mercury of the cistern, the vacuum is now secured. Care should be taken however, never again to turn the cistern bottom upward. The tube being now in a vertical position, the level of the mercury is adjusted by removing the plug from the hole *e*, when the superfluous metal escapes and the column in the tube descends, leaving the vacuum above. The plug is then to be reinserted and glued in place.

The stand (which it is well to make and fit to the tube before the latter is filled) is shown in Fig. 37. It may be of walnut, mahogany, or cherry, and its general style and finish must depend on the fancy of the maker. A shallow groove down the centre receives the tube *f*, and an oblong cavity at the bottom admits the back of the cistern, while its front may be covered with a hollow ornamental turning *g* as represented. The scale *h*, which in this case should be 5 in. long, may be ruled on ivory as already suggested, though an instrument of this description is really deserving of a well-made engraved scale, with a vernier giving readings to the hundredth part of an inch. Such a vernier *i* is a narrow piece of ivory 1¼ in. long, provided with a groove to receive the inner edge of the ivory scale along which it slides next to the tube, a hollow being cut in the wood of the stand behind the scale to admit of its motion. It is divided into 11 equal parts by 10 horizontal lines numbered downward from 1 to 10, each of the divisions measuring therefore $\frac{1}{10} - \frac{1}{100}$ in. The 30-in. line of scale is to be placed exactly 30 in. above the centre of the hole *e*, which marks the level of the mercury in the cistern. It is best to affix the scale to the stand by little brass screws. A small thermometer *k*, opposite the barometer scale, adds to the elegance and efficiency of the instrument. A slip of green surface paper should be pasted in the groove behind the tube before the latter is fixed in place. The top of the tube *f* should be covered by a small turned button *l* of bone or wood. (A. F. Miller.)

(8) **Expelling Air Bubbles from Barometer Tubes.**—First remove the tube from its board and pour out as much of the quicksilver as possible. Then invert the tube (with closed end downwards) and stand it in a warm place for an hour or more, to get warm through. Then, holding the tube firmly near both ends, make the closed end tap on a table lightly and repeatedly, and the bubbles will work up and escape. One or two thicknesses of washleather should be placed on the table for the tube to strike on, and, if necessary, the finger should be held over the upper open end to prevent any mercury flying out. To replace the mercury follow the directions already given, and if the mercury appears dirty filter through thin or pricked washleather.

(9) **Glycerine Barometer.**—The marked influences of the variations in the pressure of the atmosphere upon the disengagement of carburetted gases in coal mines has led engineers to devise a new barometer that will not only indicate the most minute variation of atmospheric pressure, but will indicate it so plainly that miners and others not experienced in making barometric observations can readily detect the variations.

(*a*) Jordan spent several years in studying the different liquids that might possibly be applicable in constructing an accurate and highly sensitive barometer, and finally found that glycerine produced the best results. The glycerine is very pure, and has a specific gravity of of 1·26, and on account of its high point of ebullition the vapours have no perceptible tension at ordinary temperatures, and it will only congeal at a very low temperature. The height of a column of glycerine is 26 ft. 9 in., and a variation of $\frac{1}{16}$ in. of mercury corresponds to a variation of about ¾ in. in the column of glycerine. As glycerine is very apt to absorb the moisture of the air, it is covered with a thin layer of prepared thickened petroleum in the cistern of the barometer. Jordan constructed barometers for the South Kensington and Jermyn Street Museums in London, and the former is

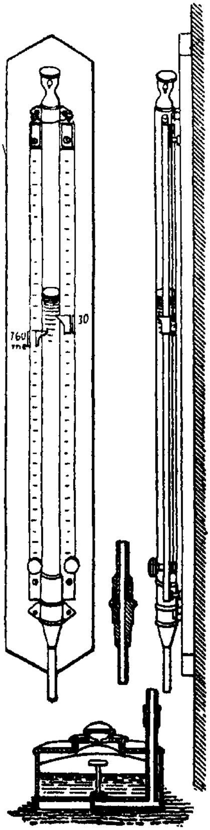


FIG. 39.

still in use (1907); both gave perfect satisfaction.

The instrument, shown in Fig. 39, was erected by him at Kew Observatory, and consists of a cylindrical cistern of tinned copper, about 6 in. high and 10 in. diameter, provided with a screw cover or cap having a small opening leading into a recess containing cotton to act as filter and keep out the dust. The large barometric tube is made of ordinary gas pipe, about ⅞ in. diameter, and is rigidly attached to the cylindrical cistern or cup. The upper end of this tube fits into a piece of bronze, into which a glass tube ⅞ in. diameter and about 4 ft. high is securely cemented. This tube terminates in a cup inclosing a rubber packing. Graduated scales provided with indicators are placed at each side of the glass tube, the one on the left side indicating the inches and tenths of inches, the right-hand scale shows the equivalent measure of a corresponding column of mercury. The scales are attached to an open plank which is fastened to the wall of one of the upper stories of the observatory, and the large tube passes down to a room situated 26 ft. 9 in. lower. The glycerine in the barometer is coloured with aniline red. Before putting the glycerine in the tube, it is boiled at a temperature of about 180° to expel the air and to make it purer. The air is exhausted from the barometer tube by means of an air pump.

(*b*) *How to make a Glycerine Barometer.*—A bottle about a quarter filled with glycerine, coloured red with magenta or crimson aniline, has a glass tube of about the diameter of a pencil passing airtight through the cork which is inserted airtight into the bottle. The lower end of the tube dips beneath the surface of the glycerine. The bottle is made to contain compressed air by blowing into the upper end of the tube. On removing the mouth, part of the glycerine will rise in the tube until the weight of the liquid column in the tube and the atmosphere balance the internal air pressure on the surface of the glycerine. The column in the tube will tend to rise when the pressure of the atmosphere diminishes, or the temperature of the compressed air rises, and to fall when the atmospheric pressure increases or the temperature of the compressed air diminishes. So far as the variation in the height of the column is due to changes in atmospheric pressure, the column moves in the opposite direction from that in a mercurial barometer.

It will now be seen that it is desirable to eliminate from the reading of the barometer scale the effect due to a change in temperature. Simultaneously observe the reading of the barometer and a thermometer at hand. Next find the difference between the readings, calling that of the thermometer the minuend. The difference is regarded as the relative pressure of the atmosphere at the time of observation. The divisions on the instrument are ¼ in. apart, and the length of the tube above the bottle is 25 in. It seems better to have 100 divisions than any other number. These divisions bear no relation to those on mercurial and aneroid barometers. Each instrument is intended to be compared with itself to indicate a relative pressure of the atmosphere. In the instrument the degrees are marked and numbered with a pen on a strip of paper obtained from a ribbon roll; this is pasted upon a neat wooden case behind the tube. The case has a recess into which the bottle is let. A piece of wood, of the proper shape, secures the bottle, while leaving it almost entirely in view. Two small wire staples secure the tube to the scale. If desirable, a paper scale may be pasted upon the tube, thus dispensing with a case.

Of course, it is liable to be broken when thus constructed. The use of a thermometer is scarcely necessary if the barometer is kept in a cellar or any place where the temperature is nearly uniform.

With a tube 3–4 ft. long, the bottle

may be buried in a large box of dry sawdust, or any other poor conductor of heat, in a finely divided state. The instrument will then give fair results without using either a thermometer or a cellar.

The advantage of using glycerine instead of water, is that glycerine scarcely evaporates; it is, however, highly hygroscopic and needs to be protected from the air by some method as in (*a*); it will not freeze except at a very low temperature, and if a minute quantity of water be present, it never becomes solid.

The upper end of the tube should be loosely filled with cotton, to keep out the dust. After having forced air into the instrument, it should not be allowed to approach a horizontal position, for the compressed air may blow the column out of the tube; if this does not happen, a large air bubble may separate the column, and render the instrument useless. No particular dimensions are requisite for either the bottle or the tube. The magenta is used merely to render the column more readily visible. Other colours may be used, but this is the most beautiful. (J. Asher.)

(10) **Portable Mercurial Barometer.**—The chief faults in the ordinary barometer are imperfect vacuum and a degree of capillarity in the mercury which makes it difficult to read the true level. With portable barometers it is rare to get accurate results. Kralvitch overcomes the obstacles by the instrument shown in Fig. 40. The two chambers *a b*, as well as the tubes joining them, are filled with pure dry mercury. The chamber *a* communicates with the chamber *d* by a capillary tube. On tipping the barometer, the mercury in *b* flows into *a*, displacing the air, which escapes by the tube *c* into chamber *d*, and cannot return to the barometric chamber *a*. The reservoir *h* assists in filling the tube, which is done cold. On reversing the tube, the air collects and escapes at the hole *o*. At *m* is a rubber tube uniting the two portions of the instrument and capable of being closed by a pinch-cock. By repeatedly reversing the tube, all air is at last forced out of the barometric chamber *a*. The instrument is rendered portable by reversing it, and putting the pinch-cock on the rubber tube.

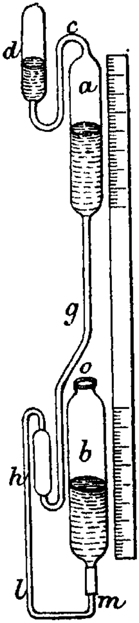


FIG. 40.

(11) **How to Read the Barometer.**—The barometer is only an extremely sensitive balance, or a manometer, showing the variations of atmospheric pressure. The early makers of one form of the instrument had the unfortunate idea of marking certain points on the dial with the words "fair," "rain," "storm," etc.; their example has been followed blindly and hence the bad reputation of the barometer. The passage of dry winds over our heads naturally causes the barometer to rise, while damp winds have the reverse effect; but it must not be forgotten that rainy winds in Europe come from the south-west, and are ascendant in latitude—they raise the air, and in the same degree lighten the barometer; on the contrary, dry winds come from the north and east, are cold, and descendent in latitude—they drive the air towards the surface of the

earth, and cause the barometer to fall. The barometer shows very well the great atmospheric perturbations—the only condition being that we should learn how to use it. The diurnal course of the sun above the horizon exercises its influence on the barometer, it heats the atmosphere, causing ascending currents of air, which create a fall in the level of the mercury in the afternoon, and a return towards the former level in the evening. It is evident that the barometer may vary from three distinct causes; by change of altitude, under the influence of dry and moist winds, and under the action of the solar rays dependent on the hour of the day. These premises being stated, it is not astonishing that two excellent instruments, one placed, for instance, at the lower, and the other at the upper part of a house, should never agree. Proprietors of certain instruments declare that theirs are the only barometers to be trusted; old friends will dispute about them. With the present mode of graduation, it is rare to find two barometers in the same house marking even the same division of the dial; the instrument which marks "variable" on the ground-floor will incline to "rain" at the fifth storey, for in a house 60 ft. high the difference in the height of the column of mercury is about 2 mm. Take a small aneroid wheel-barometer in your hand, and walk up or down a street with a sharp ascent, and you will find the needle deflect towards "fine" as you descend, and fall as you rise—every 30 ft. representing about 1 mm. in the barometric variation.

French barometers are generally graduated for Paris, and cannot possibly be correct in places of different altitudes. The position of the index is altered. The barometer is affected much by latitude, and a little by longitude; the oscillation is altered, and no change in the index will correct the error.

Suppress the deceptive indications on the dial, and the barometer may be consulted anywhere with profit. When the mercury is rising or falling, the indication of the same foretells faithfully the probable weather to be expected. The only exception occurs when two opposing currents are struggling against each other. In such a case the barometer will be scarcely affected, yet the rain may fall suddenly. Generally, rapid variations of the instrument indicate change; when the fall is rapid, rain may be expected; when very rapid, storms. The importance of the atmospheric perturbation is in proportion to the rapidity of the fall of the mercury, but the duration of bad weather is in general long in proportion as the fall has been gradual and continuous. If the mercury mounts very rapidly, the weather is not completely changed; it mounts more rapidly than it falls, but still there are differences to be observed. In testing the condition of the mercury by tapping gently with the finger, it is not safe to accept the rising of the index as a sign of fine weather; it must be remembered that the barometer, unless acted upon by a tolerably energetic current, has a marked tendency to rise between 5 o'clock in the afternoon and midnight, to fall between midnight and 5 o'clock in the morning, and to rise again between 5 a.m. and mid-day.

(12) **Baroscope.**—Take any bottle; pour coloured water into it, about ¼ of the quantity the bottle will hold; insert in it a glass tube, from 3 to 4 ft. long, and passing air-tight through the stopper, which must also be air-tight. Let a paper index, divided according to any scale of division, say into inches and fractions of an inch, be glued to the glass tube. Blow into the glass tube so as to cause the water to ascend the tube a few inches, say 10 in., and the instrument is constructed. The bottle must be placed in another vessel, and protected by sawdust, or some other material, from the influence of changes in the temperature of the atmosphere. This very sensitive instrument records faithfully any change in the density of the external air, and the approach of

a storm will infallibly be indicated by a sudden rise of the water in the glass tube.

(13) **The Aneroid Barometer** is so named from its indications being obtained without the use of mercury or any other fluid. Its action depends on atmospheric pressure on a metallic box, which has been hermetically sealed after exhaustion of air. An index, traversing a dial, records the changes in the weight or pressure of the air on a given surface. A flat circular box, about ¼ in. in depth, is made of some white metal, the upper and under surfaces of which are corrugated in concentric circles to give it greater elasticity. This box being exhausted of air through a short tube, and then made air-tight by soldering, forms a spring which is affected by every variation of pressure in the external atmosphere. It is attached to the bottom of a metallic case, which encloses the mechanism of the instrument. At the centre of the upper surface of the elastic box is a solid projection, about half an inch high, to the top of which the principal lever is attached. This lever rests partly on a spiral spring, and is also supported by two vertical pins, with perfect freedom of motion. The end of the principal lever is attached to a second or small lever, from which a chain extends to the centre, where it works on a drum attached to the arbour of the hand. A hair spring, the attachments of which are made to the metallic plate, regulates the motion of the hand.

As the weight or pressure of the atmosphere is increased or diminished, the surface of the elastic box is depressed or elevated, and this motion is communicated through the levers to the arbour of the hand. The spiral spring on which the lever rests is intended to compensate for the effects of alterations of temperature on the minute portion of air which the box must contain, however perfect the exhaustion. The actual movement at the centre of the elastic box, from which the indications emanate, is very slight, but this is increased 657 times at the point of the hand; so that a movement to the extent of one-220th part of an inch in the box, carries the point of the hand through 3 in. on the dial. The tension of the box in its construction is equal to 44 lb. At the back of the outer case is a screw, to adjust the hand to the height of a standard mercurial barometer.

BASKET MAKING.

IT may be stated at the outset that although the art of basket making is commonly thought to be confined to the use of osiers, there can be little doubt that the use of cane for this purpose is now nearly as great, particularly in the making of fancy goods. An authority has stated quite recently that as much as one-half of the cane grown and cut is now used in basket work, while bamboo is gradually growing in importance for a certain class of goods. Rushes also take a place in light and fancy articles; but although it is not the intention to treat of the use of rushes or bamboo in these pages, it may be stated that the latter is beaten flat to cause it to split into strips, and is then woven into coarse baskets and rough though strong packing hampers. With care bamboo work may be given an excellent finish, but it does not then compare favourably with osiers or cane in cost.

The Osiers, known also as willows or rods, are the stems of various varieties of *Salix* or sallows.

The green-leaved osier, or ornard (*Salix rubra*), is strong and tough, and in request for carboy baskets.

The Spaniard, or Spaniard rod. (*Salix triandra*), has several varieties, some very good and others very inferior. The black-budded Spaniard is used for the bottoms, rims, and handles of large baskets. The grey Spaniard comes in useful for coarse brown baskets. The horse Spaniard is a very poor kind.

The old common osier, being soft, of course, and brittle, is not worth cultivating in many instances; but there are some varieties of the *Salix viminalis* that are extremely useful, and the good and inferior ones bear such a close resemblance to each other that the difference often cannot be detected except in the working. The best variety is known under several names, as those of the snake osier, brindled osier, blotched osier, and speckled osier. The yellow-barked osier is also a good one, while the long skin is of smaller growth, but has the good qualities of being heavy, firm, and tough. The brownrod, brownard, or silver osier (*Salix hoffmanniana*), has a whitish hue on the under side of the leaf, eel baskets being usually made of this variety. The gelsler partakes somewhat of the nature of the Spaniard, but is of more tapering habit, with a thick butt. The new kind (*Salix forbyana*) is also akin to the Spaniard, being equally strong, but more pliable in working. The Hollander resembles the new kind in its qualities, but is different in appearance; and these may be seen growing in large quantities on the Dutch coast. The stone osier is a good kind, used for fine work.

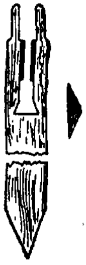
The blunt-leaved ornard (*Salix lambertiana*), the bastard French (*Salix lanceolata*), and the rose ornard (*Salix helix*), are very inferior, used only for fish baskets and hampers, their ends snapping in the working inward and outward, which consequently makes inferior work; but the bitter ornard (*Salix purpurea*) grows tough and slender, and, like all the other ornards, will thrive in water.

The French, French rod, or real French, has been imported from France, where it is much used in the manufacture of small ornamental baskets. On the Continent it is much in request by wine coopers, who bind on their wooden hoops to the wine casks with it.

The rods, or willows, as they are termed in the trade, comprise several varieties, as the skit-willow, the goldstone, or hornrod, of which there are 2 subdivisions — the wire hornrod, which is thin and tough, and the water hornrod, which is very inferior. The rods (osiers, etc.) grow best on strong and loamy soils.

Osiers are not used freshly cut; they are allowed to shrink and dry, which may take some months. To make osiers workable, they are damped in bundles, water being sprinkled on, or they are dipped in a trough of water, after which they are covered with some damp matting. When they get thoroughly damp they are pliable. Brown osiers take the longest to prepare, and require soaking under water for about 4 to 7 days. If wanted quickly hot water may be used, or even boiling may be resorted to.

Peeling Osiers.—The principal obstacle to the general cultivation of the osier is the labour of peeling it, a work that must be performed at or near the locality of its growth. The shoots are cut after the ground is frozen, to prevent the roots from being pulled from the soil in the act of cutting. They are bound in large bundles and placed in a tank, or on a level piece of ground, supported in an upright position, and water to the depth of 2–3 in. is allowed to flow over the butts. After standing until spring, the stem has absorbed water enough, by capillary attraction, to render the removal of the bark easy. This is done by drawing the shoots through a special tool consisting of a stake about 3 ft. long and 3 in. thick, with some of its heart removed by a saw for about 18 in. of its length, and cut larger at the bottom, as shown (Fig. 41).



FIGS. 41, 42.

The pieces of iron, of a section as Fig. 42, are secured by screws to the sides of the opening, the slightly rounded surfaces facing each other.

By putting an osier between the irons, pressing the top sides together with the hand and then drawing the osier through, the peel is stripped so as to be easily removed.

Cane is used either round or flat, the cane (except in large sizes) being split and finished to size, so that its natural hard polished skin is not always seen. Exception to this is in the case of chair canes, which always have one side of natural exterior surface, while others can be had either way. The sizes of canes are recognised by numbers, most cane merchants issuing illustrated price lists, or sample cards, showing the sizes. Fig. 43 will afford an idea of the sizes of some of the numbers, these being about four-fifths of full size. The round canes range from No. 00, which is about $\frac{1}{16}$ in. diameter, to No. 16, which is ¼ in.

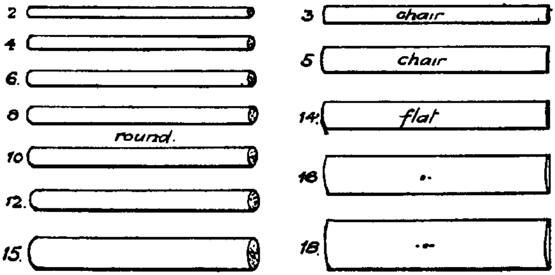


FIG. 43.

In working with cane, a suitable quantity is loosely coiled, then dipped into a tub of cold water for a few minutes, then taken out and allowed to lie wet for 20 to 30 minutes. This would be for small cane, while thicker would be allowed longer; but it should be noted, that if the cane is soaked too long it may become rough and rather spoiled.

The following remarks are extracted from a paper on "Basket Making," delivered by Thomas Okey before the Society of Arts, and reproduced by permission.

Materials and Tools.—The willows when they reach the workman are known to him as rods, which he roughly classifies as osier and fine. The former is generally used brown for coarse hamper work, and is unstripped; the latter, stripped of its skin, and used whitened or buffed, is employed in the manufacture of the finer classes of work—buff rods being rods which have been boiled before stripping, and so stained a rich light brown hue. The technical terms for the sizes into which the rods are sorted are most ancient and curious. The smaller sizes of brown are known as luke; the rising sizes, as long small, small, threepenny middleboro; and the largest, as great. The white is more carefully subdivided; and the smaller sizes are known as tack, short small, long small, etc. Ragged, is the rough twiggy stuff which is rejected as valueless for whitening purposes. Having been soaked in tanks the requisite number of hours or days, the stuff is ready for use. The tools required are few and inexpensive: a shop knife, for cutting out, Fig. 44; a picking knife, for trimming off the rough projecting ends, Fig. 45; one or two bodkins, for staking up or making handles, Fig. 46; an iron, for driving the work closely together, Fig. 47; a pair of shears, for cutting off bottom or cover sticks, Fig. 48; a dog or commander, for straightening the sticks that form the rigid framework of square baskets, Fig. 49. A screw block (Fig. 50) in which square baskets are commenced; and a cleave of boxwood for splitting osiers—usually made in two shapes, one to split into three, and one to split into four, Fig. 51. The split pieces are called skeins, and are used for sieves and finishing; the splits are then successively drawn through a shave to remove the central pith, and through an upright to render them uniform in width. This is the full kit. An ordinary round or oval basket can be made with no other implement than a knife. The employer provides a lap board, on which the basket is placed while the sides are being filled up.

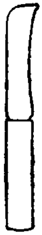


FIG. 44.

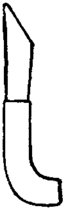


FIG. 45.

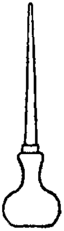


FIG. 46.

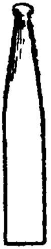


FIG. 47.

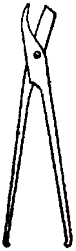


FIG. 48.

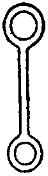


FIG. 49.

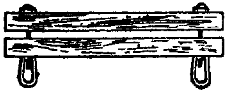


FIG. 50.

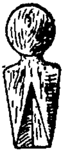


FIG. 51.

Strokes and Methods of Working.—A rod to the workmen has four different parts—the butt, the top, the belly, the back. To make a round basket, the workman first cuts off the bottom sticks from the butt end, slipes them and places them crosswise beneath his feet, and in this position proceeds to weave the bottom. He first binds them together by two rods, called slath rods, and, gradually opening out the radiating sticks, he fills the bottom up to its required width. The first task of an apprentice is confined to making these bottoms—a peculiar form of torture, known as taking the boy's backbone out. There is a method of making a round or oval bottom in a sitting position, by splitting one layer of the cross sticks with a bodkin and inserting the others. This, however, is rarely practised in this country, and it is scorned by the English workmen as fit only for women and foreigners. The bottom sticks being cut off (and if the basket is to be a common slewed one), the workman sharpens by two cuts on the back an odd number of stakes, which are to form the warp, so to speak, of the sides; these are inserted in the bottom, and then pricked up by the point of the knife, gathered into a hoop, and set up or upsetted in the direction of the body of the basket. This being done it is sided up to the requisite depth, the stakes are bordered down, and the projecting tops are cut off. This is known as the belly. If a foot is needed, it is now put on by inserting the tops cut off from the stakes alongside the upsetted stakes; the foot rods are waled, and then laid down as in a border. A cover is made in similar fashion to the bottom, and handles are fixed by twisting a rod and roping it under and over the border. The strokes chiefly used are termed: a slew, when two or more rods are woven in together; a rand, when one single rod is woven at a time; a pair, when two are woven alternately one over the other; a fitch, when two are woven alternately one under the other; this last stroke is used for making skeleton work. A wale is three or more rods woven one after and over the other to form a binding or string course. Besides common borders, many other forms, such as plaited, roped, tracked borders, are used.

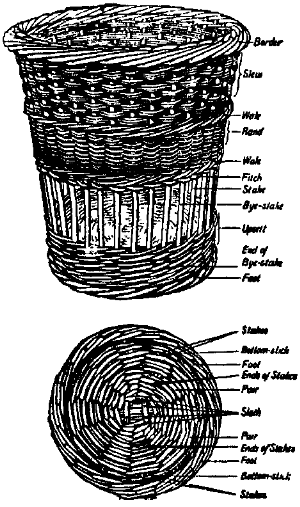


FIG. 52.

Fig. 52 is an engraving of a waste-paper basket made by Mr. Okey (with no other tool than a knife) to illustrate the chief strokes used in basket making. It will be seen that the bye-stakes are merely inserted in the upsett, whereas the stakes are driven in at each side of the bottom sticks and pricked up to form the sides. Bye-stakes are only used in fitched work.

Bottoms.—The most common example of work for a novice is to make a round mat, and, as this is similar to making the bottom of a round basket, the description may be given here. It is supposed that small cane is used so that the whole operation can be conducted with the hands and made visible for if osiers were used the booted foot has usually to be employed to hold the first cross spokes or stakes while the weaving is commenced. Fig. 53 shows how four spokes are placed to cross four spokes, when the weaving is about to be commenced. These spokes must be long enough to reach well beyond the edge of the mat (or well beyond the top of a basket), to allow of their being finished off properly at the edge or border. Now take a weaving piece or "weaver," and bind it round, over and under the four spokes, as shown at the commencement of the work in Fig. 54, going round twice or three times before "breaking out," which this illustration is intended to show. The breaking out is the beginning to take the weaver over and under each spoke separately, as shown, and at the same time the spokes are spread out more like the spokes of a wheel. After the weaver has been taken round, say twice, in this manner, it will be noticed that the weaver goes under or over the same spokes each time, and this will

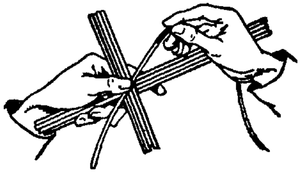


FIG. 53.

not produce a strong or proper example of basket work. To overcome this, there must be an *odd number* of spokes, when it will be found that the spokes which have the weaver go over them on one round will have it go under them the next, and this results in the true kind of basket work required. To arrange for this there has to be inserted what is known as the "odd spoke";[*] this is shown in black in Fig. 55.

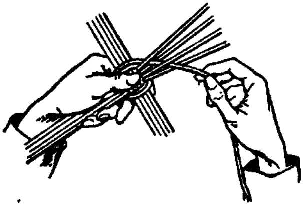


FIG. 54.

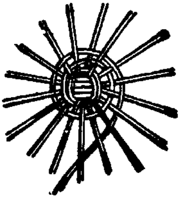


FIG. 55.

The spoke may be merely pointed and pushed in, though the best plan when it is possible (the spokes being thin), is to use the thin end of it for the first binding (as Fig. 54), only beginning with the proper weaver when about to "break out."

When the odd spoke is in, the weaving is continued without interruption, except to see that the spokes are evenly spaced, and to join a new weaver as the last one is used up. There are two or three methods of joining the weavers, that is to say, arranging for the ending of one weaver and the beginning of another. For general purposes the methods are two, these being depicted at Figs. 56 and 57. In the first, it will be seen that the end of one and the beginning of the other are bent at right angles, and, after making a space with the bodkin, these ends are tucked down one each side of a spoke. In the other, a long splice is made, the two ends being tapered off and laid together, and, being held so, they are woven in as if they were one solid weaver. Care is only required to see that the ends of the splice come against the spokes, as shown.

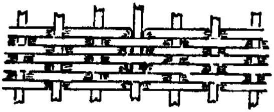


FIG. 56.

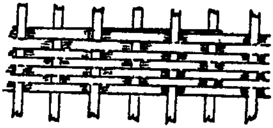


FIG. 57.

Sides.—When the circle is of correct size, the question whether the work is to be a mat or the bottom of a basket decides whether the margin or border is now to be made or not. If it is a basket, the spokes have next to be turned up as Fig. 58 (first deciding which side of the finished work shall be inside the basket), and the weaving is continued. A good plan to follow is that known as "turning up at twice," this being to turn up half the spokes, alternate ones and those which the weaver has passed over, then, having woven round one more turn, the remaining spokes are turned up. What is known as "curving" can be done in the same way, except that only a few of the spokes are turned up at the time, so as to make a curved turn instead of an abrupt angle. Curved rims may be made in this way.

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[*] The desired result can be obtained in another way, this being to start with two weavers, one over and one under, in which case an even number of spokes will do, but the general plan is to insert the odd spoke.

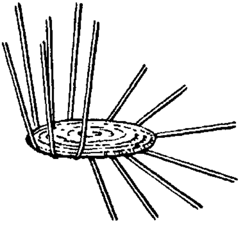

FIG. 58.

Borders.—There are quite a number of borders that can be made either plain or fancy. The common form of plain border is as Fig. 59, in which the spoke, when turned down, is first passed under the next spoke, over the following, under the next, and is then tucked down beside it. Fig. 60 is a simple open border. Needless to say, there is abundant room for the worker's ingenuity to design borders, while there are numberless examples to be seen in windows of shops dealing in fancy goods.

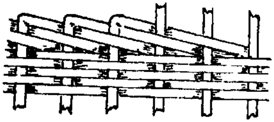

FIG. 59.

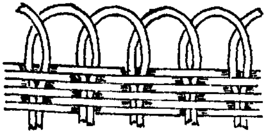

FIG. 60.

Colouring Wicker Work.—In colouring osiers, those which are boiled with the peel on are given the rich buff tint which wicker chairs usually have. A brown stain may be made of ¼ lb. permanganate of potash in 1 gal. of water; which, after application, must be followed with a second stain consisting of ½ lb. American brown potash, 2 oz. nut-galls, 1½ gal. of water, and Vandyke brown to the required shade. A mahogany colour can be obtained by first coating the wicker work with gum-water, which, when it is dry, is brushed over with a solution of bichromate of potash dissolved in hot water. The work should then be varnished with shellac varnish. A mahogany colour can also be obtained by boiling some logwood chips in water, then adding (very slowly) a small quantity of sulphuric acid. This is brushed on the work, which is afterwards varnished. (And see STAINS.)

Bleaching is a process not required for osiers, but is sometimes resorted to for cane and rush. The method is as follows. Make a suitable sized bath of boiling water, and dissolve in it 1 lb. washing soda to each gallon. Steep the cane in this for an hour to two hours. After this, wash or soak the canes in clean cold water. Make a bleaching bath by adding ½ lb. chloride of lime to each gal. of water, and immerse the canes in this for about 12 hours. Next put them in an acid bath, ½ pint sulphuric acid to each 3 qt. of water, and let the cane pass through this. Finally wash well in clean water, to ensure all acid being removed. It is best to pass some spare pieces of cane through the process first, to judge the result. (And see BLEACHING.)

Varnish for Baskets.—(*a*) Good linseed oil is boiled in a capacious vessel until a drop of it, when poured upon a cold stone slab, becomes so viscid that it strongly adheres to the finger when touched, and can be drawn out in long threads. This is mixed with 20 times the quantity of good, fat copal varnish, and the mixture is reduced with as much turpentine oil as is required to bring it to the desired consistence. To colour this varnish, if required, it is best to add aniline colours dissolved in benzol, and to mix the solution intimately with the varnish.

(*b*) Mix 1 oz. shellac and 3 oz. rosin with 1 pint naphtha; shake till well dissolved and allow to settle before use. (And see VARNISHES.)

* * *

BELL FOUNDING AND BELL METAL.

(*See also* ALLOYS, BRONZE FOUNDING, ETC.)

THE following is condensed from a paper on Clocks, Carillons, and Bells, read before the Society of Arts by Mr. A. A. Johnston.

Alloys. — (*a*) For large bells. Copper 100 lb., tin 25 down to 26 lb.

For small bells. Copper 12 lb., tin 4 lb.

(*b*) Thompson's. Copper 80 lb., tin 10·1 lb., zinc 5·6 lb., lead 4·3 lb.

(*c*) Clock bell metal. (1) Copper 75·19 lb., tin 48·81 lb. (2) German: copper 73, tin 24·3, zinc 2·7. (3) Swiss: copper 74·5, tin 25, lead 0·5.

(*d*) Parisian, for small ornamental clocks. Copper 72 parts, tin 26½ parts, iron 1½ parts.

(*e*) Locomotive bells (American). Copper 80 lb., tin 20 lb., zinc ½ lb., lead ½ lb.

(*f*) White table-bells. (1) Copper 2·06 parts, tin 97·31 parts, bismuth 0·63 parts. (2) Tin 7, antimony 1. (3) Tin 14, antimony 2. (4) Fine tone: copper 40, tin 60. (5) Tin 19, nickel 80, platinum 1.

(*g*) Gong metal. (1) Copper 78 parts, tin 22 parts. (2) Copper 78·5, tin 10·27, lead 0·52, silver 0·18. (3) Copper 10, tin 4, zinc 1·5, silver 0·5.

(*h*) For small bells, said not to tarnish, and be light in weight, and of good sound. Copper 6 lb., nickel 1 lb., melt and cool: add 1 lb. zinc and ½ oz. aluminium, melt and cool again; now finally melt, and add ½ oz. mercury and another 6 lb. of copper in a molten state.

(*i*) Japanese, and known as "Karakene." (1) Copper 20 parts, tin 8 parts, iron 1 part, zinc 3 parts. (2) Copper 20, tin 5, lead 2⅜, zinc 1. (3) Copper 20, tin 6, lead 4, iron 1, zinc 2. (4) Copper 20, tin 4, lead 4.

(*j*) Railway signal bells. Copper 60, zinc 36, iron 4.

(*k*) Sleigh bells. Copper 84, tin 16.

(*l*) Ship. Copper 82, tin 12, zinc 6.

Proportions. — The usual proportions are, to have the upper thin part of the bell one-third the thickness of the thickest part (known as the "sound-bow"). The thickness of the sound-bow varies with the size of the bell, those of large size having this part as thin as one-fifteenth the diameter, while with small ones, it has been as thick as one-tenth the diameter. These may be considered extremes, the generally accepted effective thickness of the sound bow being one-twelfth to one-thirteenth the diameter. If a peal of bells is to be undertaken, it is desirable—necessary, in fact—to adopt a rather wider range of thickness to prevent the treble being so small and weak as to be overpowered by the tenor, though care must be taken not to run into the opposite extreme and make the large bells too thin. In calculating the sizes of bells to produce particular notes, and assuming that eight bells are made of similar material, and their sections exactly similar figures, in the mathematical sense they will sound the eight notes of the diatonic scale, if all their dimensions are in these proportions: 60, 53⅓, 48, 45, 40, 36, 32, 30, which are merely convenient figures for representing the inverse proportions of the times of vibration belonging to the eight notes of the scale. So that if it is required to make a bell a fifth above a given one, it must be ⅔ of the size in every dimension, unless it is intended to vary the proportion of thickness to diameter, for the same rule then no longer holds, as a thinner bell will give the same note with a less diameter. The reason is, that according to the law of vibrating plates or springs the time of vibration of similar bells varies as $\frac{(\text{thickness})^2}{\text{diameter}}$. When the bells are also completely similar solids, the thickness itself varies as the diameter, and then the time of vibration may be said simply to vary inversely as the diameter.

Shape.—Next to the alloy of the bell, its diameter, shape and mould require close attention. A bell of a given weight must also be of a given diameter and thickness. For example, a ton bell should be 4 ft. diameter at the mouth, and 3½ in. thick at the sound-bow, whilst a 1-cwt. bell should be 18 in. diameter and 1¼ in. thick. There is no getting away from this rule if you wish your casting to turn out a success. The same principle applies to all bells of various sizes. The heavier the bell, the larger and thicker it becomes; the lighter, the smaller and thinner.

Weights.—The weights of bells of similar figures vary as the cubes of their diameters, and may be nearly enough represented by the figures 216, 152, 110, 91, 64, 46, 33, 27. The exact tune of a set of bells as they come out of the moulds is a secondary consideration to their tone or quality of sound, because the notes can be altered a little either way by cutting; but the quality of the tone will remain the same for ever, except that it grows louder for the first two or three years that the bell is used, probably from the particles arranging themselves more completely in a crystalline order under the hammering.

Moulding.—Bells of small size are generally moulded in sand from a metal or wooden pattern, and the sand mould is dried in a stove. Large bells are moulded in loam. The core is built in brick on an iron platform, which must have nugs in case the mould is made above ground. This brick core is covered with ¾ in or 1 in. thick of hair loam, and the last surface-washing is given by finely ground composition of clay and brickdust. This latter is mixed with an extract of horse-dung, to which is added a little sal-ammoniac. Upon the core the "thickness" is laid in loam sand, but the thickness is again washed with fine clay to give it a smooth surface. Ornaments which have been previously moulded, either in wax, wood or metal, are now attached by means of wax, glue, or any other kind of cement. If the ornaments are of such a nature as to prevent the lifting of the cope without them, for the cope cannot be divided, the ornaments are fastened to the thickness by tallow, or a mixture of tallow and wax. A little heat given to the mould will melt the tallow, after which the ornaments adhere to the cope, from which they may be removed when the cope is lifted off the core. It is necessary to well polish the thickness, and, as it is not possible to use coal for parting, wood ashes should be lightly dusted over. Wood ashes are also used for the parting between the core and the thickness. A paint brush is used to lay the cope on at first, the liquid, thin and fine, being made up of clay, ground brick and horse-water. Upon this hair loam, and, finally, straw loam are laid.

The moulding of the crown of the bell is done over a wood pattern after removing the spindle. In the hole in the core left by the spindle the iron or steel loop for the hammer is set, projecting into the thickness so that it will be cast into the metal when it is run. When the cope is lifted off, the facing of the mould can be finished; and if there are small defects they can be left, any excess of metal occurring at these places being chiselled off afterwards. Nothing much can be done towards polishing the facing of the mould, except to dust it uniformly with ashes, and when the mould is dry it is put together for casting. The core can be left open, or filled with sand; if open, there is no danger, as bell metal gives off very little gas. The chief security of the cope is the well-rammed sand of the pit, but it is to some extent secured by iron. The cast gate is on the top of the bell, either on the crown, or, if the crown is ornamental, at the side of it. Flow gates serve no good purpose, the metal must be clean before it is poured.

Casting.—The mould, which has previously been built up on an iron plate, is lowered into a pit already dug in the ground, of a sufficient height to envelop the bell. This mould is called the "core," and has been built up of bricks and loam, and dried hard in an oven. The core being now placed below the level of the base of the furnace, the case, which has been built up and baked in a similar manner, is then placed over it like a glove, but leaving a vacant space between the two of the prescribed thickness of the bell. Any inscription to be cast on has already been impressed on the loam of the case, so as to form part of the metal when run. The alloy having previously been mixed in the proportions already referred to, and being now reduced to liquefaction, as the result of being in the furnace some hours, the furnace is tapped, the molten metal, finding an outlet, rushes down an inclined conduit into the crown of the mould, and in a very few minutes the vacuum is filled, and the whole—core, case, and bell—are allowed to remain in the ground for a day or two to cool. A 5-cwt. bell could be dug out the next day. A ton bell would remain too hot to touch for two or three days. The process of casting is but the consummation of days and weeks of preparation.

Tuning.—The tuning of a peal of bells is a delicate business. So long as bells are used singly, it does not matter much what note they turn out; but where bells are required to act in concert with each other, then the question of tuning them to harmonise has to be taken into account. The bell is fixed mouth upwards, and held firmly in the grip of powerful vices. Having taken a plumb of the centre, we adjust our steel-cutter to the sound-bow of the bell, and proceed to pare off the metal at its thickest part. This is how a sharp bell is flattened in tone, and it can be done without detriment to the bell up to half or even three-quarters of a note. If you keep on turning it out, the bell would become thin and "panny" in sound.

To sharpen a flat bell is not so easy—indeed, we seldom attempt it, preferring rather to take the bell into stock, or even to recast, it than to waste time over what generally results in failure. There is a theory extant that a flat bell can be sharpened by reducing its diameter. I believe the note of a flat bell can be sharpened in this way, but we have also found that the application of this principle prejudicially affects the tone of the bell; hence we generally contrive to cast our bells sharp, so that they can be easily flattened, if necessary, to the required note. Sometimes they come out exactly right, and that is the best form of "tuning."

When a bell gets worn in one place through the tongue striking there for generations, it becomes weak in that particular spot, and runs the risk of cracking in consequence. What should then be done is to quarter-turn it round, so that a fresh substance is presented to the clapper as the bell swings.

Good Bell Metal has a fine grained fracture of a greyish colour, differing to bronze. It is hard, rather brittle, and sonorous. Cooled from red heat suddenly it becomes soft, but when reheated and allowed to cool very slowly it regains its hardness. The more copper in the alloy the deeper the tone, while tin, iron and zinc make the tone sharper. It has been believed that the addition of silver improved the tone, but this is now known not to be the case. In making the alloy the copper is melted first, then when the mass has been thoroughly heated the tin is added, the two being well stirred to intimately mix them. It is considered by some that best results are obtained by adding the tin in two parts: a little more than half at first, then the remainder, stirring well between.

Gong Metal has about the same composition as the bell alloy, as seen above, but the metal undergoes different treatment. After the plates are cast they are taken from the mould, and then heated in a furnace to a cherry-red heat. When in this state they are put between iron plates, plunged into water, and when cool are tough enough to be worked with a hammer. (*And see* ALLOYS).

BELTING.

(*See also* LEATHER, CEMENTS, ETC.)

A VERY useful set of instructions relating to belting was compiled by the chief general mechanical engineer of the New York Central Railway, from which the following details have been taken.

It is always best to locate the machinery (or the shafting) so that the belts shall run off from each shaft in opposite directions, as this plan affords relief to the bearings from the extra friction that must result if the belts all pull the same way. When two shafts are to be connected by one belt, it is best not to put one directly over the other, for in such a case the belt must be kept tighter than otherwise to do the work, and this means extra friction. It is desirable that the angle of the belt with the floor should not exceed 45°. Whenever possible the machines should be so placed that the direction of the belt-motion shall be from the top of the driving pulley to the top of the driven pulley. The faces of pulleys should be about one-fourth wider than their belts. When possible, the tightening of belts should be effected by moving one pulley away from the other.

The transmission of power by a belt depends upon the tension under which it is run, the degree of friction between the belt and the pulley, the complete contact of the belt with the pulley, the speed of the belt, and the arc of the pulley in contact with the belt. The tensile strength of single, ordinary tanned leather belting is about 4000 lb. per sq. in. The working strain should not exceed 10 per cent. of its tensile strength. The average leather belt will not transmit a force equal to its strength, for the reason that it will slip on its pulley before it will break.

As the friction of leather on leather is five times as great as that of leather on iron, the adhesion between the belt and the pulley can be greatly increased by covering the pulley with leather. The belt is thus capable of doing more work for a given width; the belt tension can be lessened to get the necessary friction, thus adding to the life of the belt; and unnecessary wear of the belt and a wasteful loss of power due to its slipping on the pulley are prevented. The strain to be allowed for all widths of belting—single, light double, and heavy double—is in direct proportion to the thickness of the belt, firmness of the leather being the same in all cases. Avoid running belts too tight, as great tension shortens the life of the belt, occasions a waste of power, and causes great inconvenience from hot boxes, broken pulleys, and "sprung" shafting. Belts, like gears, have a pitchline, or a circumference of uniform motion. This circumference is within the thickness of the belt, and must be considered if pulleys vary greatly in diameter and a required speed be necessary.

Belts are more satisfactory made narrow and thick, rather than wide and thin. Thin belts should not be run at a high speed, nor wide belts be made thin. Such almost invariably run in waves on the slack side, or travel from side to side of the pulley, especially if the load changes suddenly. This waving and snapping wears the belts very fast. It is greatly obviated by the use of a suitable thickness in the belts. For new belts, those that have already been filled with some good waterproof dressing are preferable to "dry" belts, for if not so filled they soon will be with lubricating oil and water, a combination that will ruin any belt. Rubber belts should be used in places exposed to the weather, as they do not absorb moisture, nor so readily stretch or decay as leather belts under like circumstances. A new belt should be made straight, and if so made will run absolutely straight if the pulleys are in line. Slots punched in the centre of a belt will allow a chance for the air to escape between the belt and the pulley, and prevent "air cushion." This is of particular advantage in all belts running at high speed.

It is safe and advisable to use a double belt on a pulley 12 in. in diameter, or larger. Light double belting runs steadily, with a minimum of "snap" or vibration, and does not twist out of place like single belting. It is successfully used for counter-belts where shifters are used, and where the work is not sufficiently hard to demand a heavy double belt; it is especially adapted for use on cone or flange pulleys, as it will keep its place and is less liable to turn over, and at the same time is pliable enough to hug the pulleys like a single belt. Double belting, light or heavy, is not recommended for twist-belts at high speed, nor for woodwork where belts are exposed to a large amount of chips or shavings, nor for places where much oil or water is liable to get on it.

As a means of making necessary alterations in the length of a belt, the laced joint is recommended. To lace a belt, cut the ends perfectly true with the aid of a try-square. Punch the holes exactly opposite each other in the two ends. The grain (hair) side of belt should be run next to the pulley, and the belt should be run off, not on to the laps. For belts 1 in. to 2½ in. wide use ¼ in. lacing; 2½ in. to 4½ in. wide, use $\frac{5}{16}$ in. lacing; 5 in. to 12 in. wide, use ⅜ in. lacing. For wider belts use wider lacing. Avoid thick lacing. In punching a belt for the lacing, it is desirable to use an oval punch, the longer diameter of the punch being parallel with the belt, so as to cut off as little of the leather as possible. There should be in each end of the belt two rows of holes staggered. Holes should be as small as possible. Recommended number of holes in the belt end for various widths is as follows:—

Width in inches	2	2½	3	4	5	6	8	10	12
Number of holes	3	4	5	7	9	11	15	19	23

The edge of any hole should not come nearer to the side of the belt than ⅝ in., nor nearer the end than ⅞ in. The second row should be at least 1¾ in. from the end of the belt. On wide belts these distances should be even a little greater. Begin to lace in the centre of belt, and take much care to keep the ends exactly in line, and to lace both the sides with equal tightness. The lacing should not be crossed on the side of the belt that runs next to the pulley.

Belts and pulleys should be kept clean and free from accumulations of dust and grease—and particularly lubricating oils, some of which permanently injure the leather. They should be well protected against water, and even moisture, unless especially waterproofed. Resin should not be used to prevent belts from slipping. If a belt slips, see first that the pulley is not dirty. Clean all the dirt from it and from the belt; rub the pulley surface of the belt with a dressing composed of 2 parts of tallow to 1 part of fish oil, rendered and allowed to cool before using. This will soften a belt and also preserve it, and it will not build up on the pulley and cause the belt to run on one side. If the belt then slips it is overloaded, and the remedy lies in a leather-covered pulley, a wider belt, or a larger pulley.

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BITTERS.

THE term "Bitters" is applied in the liquor trade to a class of compounds prepared by steeping vegetable bitters in weak spirit for some days, with the addition of aromatic flavourings, syrup and colouring matter. The following are the chief kinds :—

Amazon.—90 gal. plain proof spirit ; 3¼ lb. red Peruvian bark ; 3¼ lb. calisaya bark ; 1½ lb. calamus root ; 4¾ lb. orange peel ; 3½ oz. cinnamon ; 3½ oz. cloves ; 3½ oz. nutmeg ; 2 oz. cassia buds ; 6½ lb. red sanders wood. First mash all the ingredients, put them in the spirit, and let them infuse 14 days, stirring the mixture well twice every day. Rack off and colour with 11 pints brandy colouring, to get a dark red tint. Stir ¼ hour. Dissolve 30 lb. white sugar in 30 gal. water ; add, and again stir ½ hour. Let the mixture rest 4 or 5 days, and when bright, bottle. If the sanders wood is not used the colour will be a bright amber, Compounded according to the above directions will yield 120 gal. 25° below proof.

Angostura.—4 oz. gentian root ; 10 oz. each calisaya bark, Canada snake-root, Virginia snake-root, liquorice root yellow bark, allspice, dandelion root, and Angostura bark ; 6 oz. cardamom seeds ; 4 oz. each balsam of tolu, orangetis, Turkey rhubarb, and galanga ; 1 lb. orange peel ; 1 lb. alkanet root ; 1½ oz. caraway seed ; 1½ oz. cinnamon ; ½ oz. cloves ; 2 oz. each nutmegs, coriander seed, catechu and wormwood ; 1 oz. mace ; 1¼ lb. red sanders wood, and 8 oz. turmeric. Pound these ingredients and steep them for 15 days in 50 gal. proof spirit ; before filtering, add 30 lb. honey.

Aromatic. — Macerate 2¾ lb. ground dried small orange apples, ¼ lb. ground dried orange peel, 2 oz. ground dried calamus root ; 2 oz. ground dried pimpinella root ; 1 oz. ground dried cut hops, for 14 days, with 10 gal. of spirit at 45 per cent. ; press and add 2½ pints brown sugar syrup. Filter. Colour dark brown.

Boker's.—1½ oz. quassia ; 1½ oz. calamus ; 1½ oz. catechu (powdered) ; 1 oz. cardamom ; 2 oz. dried orange peel. Macerate for 10 days in ½ gal. strong whisky, and then filter and add 2 gal. water. Colour with mallow or malva flowers.

Brandy.—(1) Grind to coarse powder 3 lb. gentian root, 2 lb. dry orange peel, 1 lb. cardamom seeds, 2 oz. cinnamon, 2 oz. cochineal. Infuse 10 days in 1 gal. brandy, 8 gal. water, and filter.

(2) Take a gallon of gin (17 or 20 under proof) and steep in this for 6 days, 2 oz. of pulverised coriander seeds and ½ lb. Virginia snake-root. It should be shaken 3 or 4 times each day, and at the expiration of 6 days it may be strained off. Take ½ pint of spirits of wine, and put in it ½ an oz. of the oil of Seville orange peel and ¼ oz. of oil of caraway, shake well together and let stand 6 days. Then add to the whole ½ gal. of clarified sugar and 6 gal. of waste, or the lowest gin or rectified spirits, whichever are available, and lastly add 2 gal. of water. Fine down with an ounce of roach alum dissolved. These are good bitters, and the quantities given will make 10 gal. It is as well to let it stand a week, then draw off and put into a clean cask. Before doing this it can be coloured with burnt sugar or caramel to the requisite brandy tint.

Essence.—40 gal. proof spirit ; 1 dr. oil of anise ; 1 dr. oil of caraway ; ½ dr. oil of cloves ; 1 dr. oil of lemon ; 1 dr. oil of oranges ; 1 dr. oil of cinnamon ; ½ dr. oil of bitter almond ; 1 gal. sugar syrup. Put the oils in 95 per cent. alcohol, and mix. Colour with brandy colouring.

French Cognac.—1½ lb. each red Peruvian bark, calisaya bark, bitter orange peel, and sweet orange peel ; 2 oz. calamus root ; 4 oz. cardamom seeds ; 1½ oz. each cinnamon, cloves, and nutmegs ; 4 oz. caraway seed ; and 3 lb. wild cherry bark. Pound all these ingredients to a coarse powder, and steep for 15 days in 45 gal. proof spirit (or 60 gal. spirit 25° below proof), stirring occasionally. Then rack it off, and mix sufficient caramel to make it a dark red; add 15 lb. white sugar dissolved 15 gal. water; let the whole settle, then filter. If the bitters are required to be of an amber colour, omit the wild cherry bark and the caramel colouring.

Hamburg.—Grind to a coarse powder 2 oz. agaric, 5 oz. cinnamon, 4 oz. cassia buds, ½ oz. grains of paradise, 3 oz. quassia wood, ¾ oz. cardamom seeds, 3 oz. gentian root, 3 oz. orange apples dried, 1½ oz. orange peel. Macerate with 4¼ gal. 95 per cent. alcohol, mixed with 5¾ gal. water; add 2¾ oz. acetic ether. Colour brown.

Nonpareil.—Grind to coarse powder 2 oz. Peruvian bark, ½ oz. sweet orange peel, ½ oz. bitter orange peel, 25 gr. cinnamon, 25 gr. cloves, 25 gr. nutmeg, 15 cayenne seeds. Infuse 10 days in 2 gal. 65 per cent. alcohol, then filter.

Orange.—(1) Macerate 6 lb. orange peel for 24 hours with 1 gal. water, cut the yellow part of the peel from off the white, and chop it fine; macerate with 4¾ gal. 95 per cent. alcohol for 2 weeks, or displace; then add a syrup made of 4¼ gal. water and 16 lb. sugar. Filter through Canton flannel.

(2) ½ oz. Seville orange peel; ¼ oz. lemon peel; ¼ oz. gentian root; ¼ oz. ginger, all bruised and put into a jug; pour a pint of boiling water on it, and cover up with a cloth; let it stand ½ hour, strain, and add 2 tablespoonfuls of brandy as preservative.

Peruvian.—8 oz. red Peruvian bark; 8 oz. orange peel; 1½ dr. each cinnamon, cloves, and nutmeg; and 75 cayenne pepper seeds. Infuse them, well bruised, in 8 gal. proof spirit, for 15 to 20 days, stirring every day. Draw off and filter.

Spanish.—Grind to coarse powder 6 oz. polypody, 6 oz. calamus root, 8 oz. orris root, 2½ oz. coriander seed, 1 oz. centaurium, 3 oz. orange peel, 2 oz. German chamomile flowers; then macerate with 4¾ gal. 95 per cent. alcohol, and add 5¼ gal. water and 1⅛ oz. sugar. Filter, and colour brown.

Stomach.—Grind to a coarse powder ½ lb. cardamom seeds, ⅛ lb. nutmegs, ¼ lb. grains of paradise, ½ lb, cinnamon, ¼ lb. cloves, ¼ lb. ginger, ¼ lb, galanga, ¼ lb. orange peel, ⅛ lb. lemon peel; then macerate with 4¾ gal. 95 per cent. alcohol, and add a syrup made of 4½ gal. water, and 12 lb. sugar; filter.

Stoughton.—(1) To 12 lb. dry orange peel, 3 lb. Virginia snake-root, 1 lb. American saffron, 16 lb. gentian root, add 1 lb. red sanders wood. Grind all the ingredients to a coarse powder, and macerate for 10 days in 20 gal. 65 per cent. alcohol, then filter.

(2) 2 lb. ginseng; 2 lb. gentian root; 1½ lb. dry orange peel; ½ lb. Virginia snake-root; 1 oz. quassia; ¼ lb. cloves; 3 oz. red sanders wood; 3 gal. alcohol 95 per cent.; 3 gal. soft water. Grind all the ingredients to coarse powder, infuse 10 days, and filter.

Wild Cherry.—Wild cherry bark, 4 lb.; squaw vine (Partridge berry), 1 lb.; juniper berries, 8 oz. Pour boiling water over, and let stand for 24 hours; strain, and again pour boiling water on the ingredients; let macerate for 12 hours, then express and filter through paper, so that the whole will make 5 gal., to which add 3½ lb. of sugar, 1½ gal. molasses, 6 oz. tincture of peach kernels, 3 oz. tincture of prickly ash berries, 2 qt. alcohol.

Wine.—4 oz. Seville orange peel, 4 oz. Virginia snake-root, 8 dr. of long pepper, 1 gal. of Cape wine. Steep all together for a week, then strain through flannel, and use.

Wormwood.—4 dr. of oil of Seville orange peel, 2 dr. oil of caraway, 2 dr. oil of wormwood, ½ oz. almond cake, 1 oz. coriander seed, 1 oz. Virginia snake-root, ½ gal. clarified sugar, 4 gal. clear rectified spirits. Make up to 6 gal. with water. The coriander seeds, almond cake and snake-root should be steeped in the spirits for 3 or 4 days, and the different oils killed in spirits of wine.

BLACKBOARD WASH OR "LIQUID SLATING."

(*See also* PAINTING.)

(1) 4 pints 95 per cent. alcohol, 8 oz. shellac, 12 dr. lampblack, 20 dr. ultramarine blue, 4 oz. powdered rotten-stone, 6 oz. powdered pumice.

(2) 1 gal. 95 per cent. alcohol, 1 lb. shellac, 8 oz. best ivory black, 5 oz. finest flour emery, 4 oz. ultramarine blue. Make a perfect solution of the shellac in the alcohol before adding the other articles. To apply the slating, have the surface smooth and perfectly free from grease; well shake the bottle containing the preparation, and pour out a small quantity only into a dish, and apply it with a new flat varnish brush as rapidly as possible, Keep the bottle well corked, and shake it up each time before pouring out the liquid.

(3) Lampblack and flour of emery mixed with spirit varnish. No more lampblack and flour of emery should be used than are sufficient to give the required black abrading surface. The thinner the mixture the better. Lampblack should first be ground with a small quantity of spirit varnish or alcohol to free it from lumps. The composition should be applied to the smoothly-planed surface of a board with a common paint-brush. Let it become thoroughly dry and hard before it is used, Rub it down with pumice if too rough.

(4) ½ gal. shellac varnish, 5 oz. lampblack, 3 oz. powdered iron ore or emery; if too thick, thin with alcohol. Give 3 coats of the composition, allowing each to dry before putting on the next; the first may be of shellac and lampblack alone.

(5) ½ lb. logwood and sufficient boiling water to cover it; allow it to stand for twenty-four hours. Strain, and allow the solution, boiling, if possible, twice, allowing the board to dry in the interval. Then dissolve ¼ lb. of copperas in about 1 pint of boiling water, and apply it boiling, once or twice, according to the degree of blackness obtained. Before using it, rub it over well with rushes, straw, ferns, or shoemakers' heel ball. It may be a little difficult to rub the chalk off at first, but after a fortnight's use that will disappear. Use unprepared chalk, which writes well.

(6) Heat ¼ lb. lampblack on a flat piece of tin or iron on a fire till it becomes red, take it off, and leave it until sufficiently cool, when it must be crushed with the blade of a knife on a flat board quite fine; then get ½ pint of spirits of turpentine, mix both together, and apply the mixture with a size brush. If the board is new, it would be well to give it one or two coats of lampblack—not burnt, but mixed with boiled oil—adding ½ lb. of patent driers. After the board is thoroughly dried, apply the burnt lampblack and turpentine. The preparation must be laid on quickly.

(7) Dissolve 4 oz. shellac in 1 qt. alcohol; add lampblack, 6 dr.; ultramarine blue, 1 dr.; pumice stone, powdered, 3 oz.; rotten-stone, powdered, 2 oz. Have the board dry and free from grease before painting it.

(8) To make 1 gal., take 10 oz. pulverised and sifted pumice, 6 oz. powdered rotten-stone, ¾ lb. good lampblack, and alcohol enough from 1 gal. to form, with these, a thick paste, which must be well rubbed and ground together. Then dissolve 14 oz. shellac in the remainder of the gal. of alcohol by digestion and agitation, and finally mix this varnish and the paste together. It is applied to the board with a brush, care being taken to keep the paint well stirred, so that the pumice will not settle. Two coats are usually necessary. The first should be allowed to dry thoroughly before the second is put on, the latter being applied so as not to disturb or rub off any portion of the first. 1 gal. of this paint will ordinarily furnish two coats for 60 sq. yds. of blackboard. When the paint is to be put on plastered walls, the wall

should be previously coated with glue size—1 lb. glue, 1 gal. water, enough lampblack to colour; put on hot.

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BLACKINGS AND LEATHER POLISHES.

MOST leather articles while in use require the periodical application of a preservative varnish to give them a finished appearance, and protect them from decay and surface wear. Such varnishes go by various names, but are most commonly known as "blacking," being originally intended to give a black polish. Blacking is a pasty compound used especially on the "uppers" and the edges of the soles and heels of boots and shoes. There are numerous methods of manufacturing this substance; but in nearly all, the base is a black colouring matter, commonly bone charcoal, mixed with substances which acquire a gloss by friction, such as sugar and oil. The carbon employed should be in the form of a very deep, finely powdered black. Since it always contains lime carbonate and phosphate, it is treated with a mineral acid in order to decompose these salts; a mixture of sulphuric and hydrochloric acids is frequently used, the salts produced being lime acid phosphate, sulphate and chloride. The lime sulphate gives consistence to the pasty mass, and the two other salts being deliquescent help to keep the leather flexible. No more acid should be used than is sufficient to decompose these salts, or the leather will be injured. It is probably to prevent this that some makers add a small quantity of alkali to the blacking. Sometimes powdered gall-nuts, iron sulphate, indigo, and Prussian blue are incorporated with the blacking in order to impart to it a good colour. Fatty or oily matters are also sometimes added in order to preserve the flexibility of the leather, and to neutralise any excess of acid which may remain. The consistence of different blackings varies widely.

Liquid Boot Polishes.—(1) The well-known liquid blacking of Day and Martin is composed in the following manner. Very finely ground animal charcoal, or bone-black, is mixed with sperm oil till the two are thoroughly commingled. Raw sugar or treacle, mixed with a small portion of vinegar, is then added to the mass. Next a small measure of dilute sulphuric acid is introduced, which by converting into sulphate a large proportion of the lime contained in the animal charcoal, thickens the mixture into the required pasty consistence. When all effervescence has subsided, but while the compound is still warm, vinegar is poured in until the mass is sufficiently thinned; then it is ready to be bottled for the market.

(2) Animal charcoal, 5 oz.; treacle 4 oz.; sweet oil, ¾ oz.; triturate until the oil is thoroughly incorporated, then stir in gradually ½ pint each vinegar and beer lees.

(3) Animal charcoal, 1 lb.; sperm oil, 2 oz.; beer and vinegar, each 1 pint, or sour beer, 1 qt.

(4) Bryant and James's indiarubber blacking. Indiarubber in very fine shreads, 18 oz.; hot rapeseed oil, 9 lb. (1 gal.); animal charcoal in fine powder, 60 lb.; treacle, 45 lb.; gum arabic, 1 lb., previously dissolved in vinegar, No. 24 strength, 20 gal. The mixture is triturated in a colour-mill until perfectly smooth, then placed in a wooden vessel, and sulphuric acid is added in small successive quantities amounting altogether to 12 lb. This is stirred for ½ hour daily for 14 days, then 3 lb. of finely-ground gum arabic are added, and the stirring is repeated for an additional 14 days, when the blacking will be ready for use.

(5) A good liquid polish is made by mixing together 4 oz. of gum arabic; 1½ oz. of treacle or coarse moist sugar; ½ pint of good black ink; 2 oz. of strong vinegar; 1 oz. of rectified spirit of wine; and 1 oz. of sweet oil. Dissolve the gum in the ink, add the oil, and

shake together until they are thoroughly mixed. Then add the vinegar, and, lastly the spirit. Keep in a tightly corked bottle.

(6) Acmé blacking. To 1 gal. rectified spirit is added 21 dr. blue aniline, and 31 dr. Bismarck brown aniline, the solution of the two last being effected by agitation for 8–12 hours. After the solution is completed, the mass is allowed to settle, and the liquid portion is drawn off by spigots above the sediment, and filtered if necessary. The alcohol is placed in the apparatus first, then the colours, and the mixture agitated every hour for a space of 10–15 minutes. Of this liquid, ¼ gal. is added to 1 gal. rectified spirit, and in this are dissolved 11 oz. camphor, 16 oz. Venice turpentine, 36 oz. shellac. To 1 qt. benzine, add 3⅙ fl. oz. castor-oil, and 1⅗ fl. oz. boiled linseed-oil. The two solutions are then united by agitation, but should not be allowed to stand over 2 days in any vessel of iron or zinc, as in the presence of the gums the colours will be decomposed by contact with zinc in 8 days, and with iron in 18–24 days.

(7) A quantity of ordinary starch is dissolved in hot water, and while still hot, oil or wax is added; the mixture is stirred and allowed to cool. When cold, a small quantity of iodine is added to give a bluish-black colour. To 1 gal. of this are added 8 oz. of a solution of iron perchloride or other *per* salt, a small quantity of gallic or tannic acid (or both), and sometimes about 2 dr. of oil of cloves with 8 oz. glycerine. The whole is thoroughly stirred.

(8) Nicolet, of Lyons, prep[illegible] boot blacking by dissolving 150 parts wax and 15 of tallow in a mixture of 200 of linseed-oil, 20 of litharge, and 100 of molasses, at a temperature of 230° to 250° F. (110° to 120° C.). After this, 103 parts lampblack are added, and when cold it is diluted with 280 of spirits of turpentine, and finally is mixed with a solution of 5 of gum lac and 2 of aniline violet in 35 of alcohol.

(9) Hein, in Kaufering, makes another kind of shoe blacking by melting 90 parts beeswax or ceresine, 30 of spermaceti, and 350 of spirits of turpentine, with 20 of asphalt varnish, and adds 10 of borax, 20 of lampblack, 10 of Prussian blue, and 5 of nitrobenzol.

(10) Brunner uses 10 parts boneblack, 10 of glucose syrup, 5 of sulphuric acid, 20 of train oil, 4 of water, and 2 of soda carbonate. The boneblack and glucose are stirred with the acid in a porcelain vessel until the whole mass is homogeneous and has a shining black surface when at rest. The soda is dissolved in a little water, and boiled with the oil under constant stirring until it forms a thick liquid; then the other mixture is stirred into it. By varying the proportions of these two mixtures, the blacking is made thinner and softer, or harder and firmer. The substances sold as French polish are mostly composed of these ingredients. In this and all other kinds of shoe blacking made with bone-black and sulphuric acid, the precaution must be observed of stirring rapidly and evenly after the acid is added, otherwise lumps will be formed that are difficult to crush, and the blacking will have a granular condition that should not exist. Good shoe blacking must always remain soft, and show a smooth uniform surface when applied to the leather.

(11) A good liquid blacking may be prepared by mixing 3 lb. lampblack with 1 qt. stale beer, and ¼ pint sweet oil, adding thereto 1 oz. treacle, ¼ oz. green copperas, and ¼ oz. logwood extract. This furnishes a blacking which polishes easily and well.

(12) Cheap and good shoe blacking.— To 1 lb. best ivory black add 1 lb. treacle, 8 tablespoonsfuls sweet oil, dissolve 1 oz. gum arabic in 2 qt. vinegar, with ¼ lb. vitriol (sulphuric acid).

(13) Guttapercha. — To 30 parts syrup, contained in a boiler, add 9 of lampblack and 1¼ of finest bone-black, and mix the whole intimately together. Heat 1¼ part guttapercha, cut into small pieces, in a kettle over a coal-fire, until it is nearly all melted, add

to it gradually, under constant stirring, 2½ parts olive-oil, and when the guttapercha is all dissolved, ½ part stearin. Pour the latter mixture, while still warm, very slowly and gradually into the first-mentioned mixture, and when the whole has been thoroughly incorporated, add a solution of 2$\frac{1}{10}$ part gum senegal in 6 of water, likewise stirring. Finally, the product may be aromatised by the addition of 1$\frac{1}{10}$ part rosemary or lavender oils. This blacking produces a fine gloss of a deep black. It is not injurious to leather.

(14) Take ivory- or bone-black, any quantity, and to every pound put 1½ oz. measure of sulphuric acid, and well triturate it. It will become damp, like snuff. Next add cod oil, 2 oz. to the lb. If to be liquid, add treacle, 3 oz. to the lb., and small beer to mix, or stale beer if for paste, enough to make up into a paste. Foots-sugar is preferable to treacle, and a better black is got by adding ¼ oz. to the lb. of Prussian blue. It is improved if laid up light for a day or two after the first manipulation, and again after the second, as a decomposition takes place.

(15) A fine, brilliant, elastic dressing for leather can be made as follows: To 3 lb. of boiling water add, with continual stirring, ½ lb. white wax, 1 oz. transparent glue, 2 oz. gum senegal, 1½ oz. white soap, and 2 oz. brown candy. Finally, add 2½ oz. alcohol, and, after the whole is cooled, 3 oz. fine Frankfort black. The dressing is thinly applied to the leather with a soft brush, and after it is dried it is rubbed with a piece of fine pumice and polished with a stiff brush.

(16) 7 lb. each ivory black and treacle, well mixed with 2 qt. boiling water; add 2 lb. 10 oz. vitriol, and the previously thin liquid will become quite thick. After the effervescence has ceased, add 1 pint of any common oil,—fish-oil is the best. If you want it liquid, add stale beer or vinegar.

(17) Useful blacking for leather may be made thus: Dissolve 11 lb. of green vitriol and 5 lb. tartaric acid in 9 gal. water. After the settling, draw off the clear liquid; then boil 16 lb. logwood with about 18 gal. water, and 11 gal. of the fluid. Let the boiled mixture stand for about 8 days, pour it off from the sediment, dissolve in it 2 lb. grape sugar, and mix this liquid with the green vitriol solution. The blacking so obtained may be made still brighter by mixing the logwood decoction with 4 lb. aniline black-blue before the addition of the vitriol. The application of the blacking is very simple. The leather is first well-brushed with a solution of soda, or still better with a spirit of sal-ammoniac, in 25 times as much water, to get rid of the grease. The blacking is then applied with the proper brush for the purpose.

(18) Finishing black.—Mix together ½ oz. each gelatine and indigo, 1 oz. logwood extract, 2 oz. crown soap, 8 oz. softened glue, and 1 qt. vinegar; heat the whole over a slow fire, and stir until thoroughly mixed. Apply with a soft brush, and polish with a woollen cloth.

(19) Mix a quantity of bone-black with equal parts of neat's-foot oil and brown sugar, in proportions to produce a thick paste; then with vinegar and sulphuric acid in proportions of 3 parts of the former to 1 of the latter.

(20) Melt 2 lb. wax, and add ¼ lb. washed and well-dried litharge by screening it through a fine sieve; then add 6 oz. ivory black, and stir until cool, but not cold; add enough turpentine to reduce it to a thin paste, after which add a little birch or other essential oil to prevent it from souring.

(21) A liquid black is made by mixing 3 oz. ivory black with 1 tablespoonful citric acid, 2 oz. brown sugar, and a small quantity of vinegar, afterward adding 1 oz. each sulphuric and muriatic acids; mix the whole together, and add a sufficient quantity of vinegar to make 1 pint in all.

(22) Vinegar, 2 pints; soft water, 1 pint; glue (fine), 4 oz.; logwood chips, 8 oz.; powdered indigo, 2 dr.; potash bichromate, 4 dr.; gum traga-

canth, 4 dr.; glycerine, 4 oz. Boil, strain, and bottle.

(23) A German journal gives the following: Mix 200 parts shellac with 1000 of spirit (95 per cent.) in a well-stoppered bottle. Keep in a warm place for 2–3 days, shaking frequently. Separately dissolve 25 parts Marseilles soap in 375 of warmed spirit (25 per cent.), and to the solution add 40 of glycerine. Shake well and mix with the shellac solution. To the mixture add 5 parts nigrosin dissolved in 125 of spirit. Well close the vessel and shake energetically, and then leave the mixture in a warm place for a fortnight.

(24) Ivory black, 6 lb.; treacle, 4 lb.; gum arabic (dissolved in hot water), 2 oz.; vinegar, 2 gal.; sulphuric acid, 2½ lb.; indiarubber dissolved in about 1 pint of oil, 2 oz. Mix well together. This blacking may be applied by means of a brush, or a small sponge attached to a piece of twisted wire.

(25) Boot Top Liquid.—Oxalic acid, 1 oz.; white vitriol, 1 oz.; water, 30 oz. Dissolve, and apply with a sponge to the leather, which should have been previously washed with water; then wash the composition off with water, and dry. This liquid is poisonous.

(26) A waterproof blacking, which will give a fine polish without rubbing, and will not injure the leather: 18 parts beeswax, 6 spermaceti, 66 turpentine oil, 5 asphalt varnish, 1 powdered borax, 5 vine twig (Frankfort) black, 2 Prussian blue, 1 nitrobenzol. Melt the wax, add powdered borax, and stir till a kind of jelly has formed. In another pan melt the spermaceti, add the asphalt varnish, previously mixed with the turpentine oil, stir well, and add to the wax. Lastly add the colour previously rubbed smooth with a little of the mass. The nitrobenzol gives fragrance.

Paste Blackings.—Most of the latest recipes for paste blackings, as put up in fancy tins, have cod-liver oil as a chief ingredient, hence their higher cost than the ordinary paste blackings put up in paper.

(1) Mix 10 lb. of bone-black with 2½ lb. sulphuric acid, add 2 pints of cod-liver oil, then 2 lb. of treacle, and 2½ oz. of finely powdered Prussian blue. Mix well together and reduce the stiffness, if necessary, with stale beer.

(2) 1 lb. beeswax melted in an earthenware jar. Stir in ¼ lb. ivory black, 2 oz. Prussian blue (ground in oil), and 2 oz. oil of turpentine. Lastly add ½ oz. of copal varnish. This is applied with a brush, and polished with a cloth or velvet pad.

(3) Bryant and James's indiarubber blacking (see Liquid boot polishes (4)) may be made in a solid form by reducing the proportion of vinegar from 20 gal. to 12. The compound then only requires stirring for about 6 or 7 days in order to prepare it for use, and it may be liquefied by subsequent addition of vinegar.

(4) Dr. Artus manufactures blacking from the following materials: Lamp-black, 3 or 4 lb.; animal charcoal, ½ lb.; are well mixed with glycerine and treacle, 5 lb. Meanwhile gutta-percha, 2½ oz., is cautiously fused in an iron or copper saucepan, and to it is added olive-oil, 10 oz., with continual stirring, and afterwards stearine, 1 oz. The warm mass is added to the former mixture, and then a solution of 5 oz. gum senegal, in 1½ lb. water, and 1 dr. each of rosemary and lavender oils may be added. For use it is diluted with 3-4 parts of water, and tends to keep the leather soft, and render it more durable.

(5) All ordinary paste blackings require to be mixed with some liquid before application, causing considerable waste. It is claimed for the subjoined method of preparation, that by its means the blacking is rendered of such a condition that when merely dipped in water or other solvents the required quantity can be rubbed on to the article to be blacked without the cake crumbling or breaking up. The ingredients of the blacking are those in ordinary use, but it is brought to the required consistence by combination with Russian tallow, in the proportion

of 3 per cent., and casting the mass into the desired forms. These may be cylindrical, etc., and may be enclosed in covers of cardboard, tinfoil, etc., in which the blacking can slide, so that when one end is pushed out for use, the remainder acts as a handle. The exposed end, when damped by immersion or otherwise, can be rubbed on the article without crumbling. The ivory black (animal charcoal) which has been used in the preparation of white paraffin, according to Letchford and Nation's patent, may be conveniently used for making blacking.

(6) The addition of sulphuric acid to animal charcoal and sugar produces lime sulphate and a soluble acid lime phosphate, which makes a tenacious paste. Thus: Animal charcoal, 8 parts; molasses, 4; hydrochloric acid, 1; sulphuric acid, 2. These are well mixed. A liquid blacking may be produced from this by the addition of the necessary proportion of water.

(7) To 1 lb. animal charcoal add 4 oz. commercial sulphuric acid; work them well together, and when the acid has done its duty upon the charcoal add 4 oz. fish or colza oil; stir the mixture till the oil is thoroughly incorporated, then pour in gradually a strong solution of washing soda or other suitable alkali, and continue the stirring till ebullition ceases, or the acid is neutralised. Next add about 8 oz. treacle, and then pour in a solution of gelatine and glycerine, in quantity about 2 qt. if liquid blacking is required, but less will suffice to produce paste. The solution of glycerine and gelatine is made by dissolving the best size in hot water, in the proportion of 4 parts water to 1 of size, and then adding to every qt. of the liquid 1¼ oz. glycerine. The addition of the glycerine and gelatine preparation gives great brilliancy, depth of colour, and permanency to the blacking when applied to leather, and at the same time makes it damp-proof; besides which the alkali has the effect of neutralising the sulphuric acid employed, and thus prevents the injurious action of that acid on the leather, as in the case of most ordinary blackings.

(8) A leather varnish or polish is prepared by Gunther, of Berlin, by mixing a filtered solution of 80 parts shellac in 15 of alcohol, with 3 of wax, 2 of castor oil, and a sufficient quantity of pigment. The mixture is evaporated *in vacuo* to a syrup. The varnish is applied to the leather with a brush moistened with alcohol or with a colourless alcoholic varnish.

(9) Soften 2 lb. good glue, and melt it in an ordinary glue kettle; then dissolve 2 lb. Castile soap in warm water and pour it into the glue; stir until well mixed, and add ½ lb. yellow wax cut into small pieces; stir well until the wax is melted, then add ½ pint neat's-foot oil and enough lampblack to give the desired colour. When thoroughly mixed, it is ready for use.

(10) *Waterproof.* — Melt together 4 oz. black rosin and 6 oz. beeswax over a slow fire; when thoroughly dissolved, add 1 oz. lampblack and ¼ lb. finely powdered Prussian blue; stir the mixture well, and add sufficient turpentine to make a thin paste. Apply with a cloth and polish with a brush.

(11) *Liebig's.*—Mix bone-black in ½ its weight of molasses, and ⅛ its weight of olive-oil, to which add ½ its weight of hydrochloric acid and ¼ its weight of strong sulphuric acid, with a sufficient quantity of water to produce a paste.

(12) Molasses, 1 lb.; ivory black, 1¼ lb.; sweet oil, 2 lb. Rub together in a Wedgwood mortar till all the ingredients form a perfectly smooth homogeneous mixture; then add a little lemon juice or strong vinegar—say the juice of one lemon, or about a wineglassful of strong vinegar—and thoroughly incorporate, with just enough water added slowly to gain the required consistency.

(13) Ivory black, 2 lb.; molasses, 1 lb.; olive-oil, ¼ lb.; oil of vitriol, ¼ lb. Add water to gain required consistency.

(14) Take 1 part ivory black ¼ of melted tallow, and work up well in a

mortar. Incorporate with this paste ½ part treacle, ¼ of sulphuric acid, and ⅛ of spirits of salt. This will form an excellent paste blacking.

Dress Boots.—The following compositions are prepared: (1) Gum arabic, 8 oz.; molasses, 2 oz.; ink, ½ pint; vinegar, 2 oz.; spirit of wine, 2 oz. Dissolve the gum and molasses in the ink and vinegar, strain, and then add the spirit of wine.

(2) Mix together the whites of 2 eggs, 1 teaspoonful spirits of wine, 1 oz. sugar, and as much finely pulverised ivory black as may be required to produce the necessary shade of black. Apply with a sponge, and polish with a piece of silk.

(3) Mix together ½ lb. each ivory black, purified lampblack, and pulverised indigo, 3 oz. dissolved gum arabic, 4 oz. brown sugar, and ¼ oz. glue dissolved in 1 pint water; heat the whole to a boil over a slow fire, then remove, stir until cold, and roll into balls.

Polish for Glacé Kid Boots. Take 20 oz. of methylated spirits and dissolve in it 3 oz. of pale gum sandarach. It will require frequent shaking to dissolve the gum. Add ivory black and just a little glycerine. The latter aids in keeping the polish.

Brown Boot Polish.—(1) ½ lb. turpentine, 5 oz. white wax, ½ lb. water. Boil the wax in the water and add a good pinch of potassium carbonate. Stir till nearly cold, then add the turpentine (away from the fire). This is applied with a brush or sponge, and polished with a velvet pad. (2) Put ¼ lb. pearlash in a little water to boil and scrape into it 2 lb. beeswax and 1 lb. good yellow soap. Let the whole boil until all is dissolved. Stir well until the mixture is of even consistence and allow it to cool a little. Next mix in 4 lb. of turpentine, and, lastly, ¼ lb. methylated spirits. Water can be added, if required, to make a cream. The cream is applied to the leather, dry polished with a brush, and then finished with a cloth.

(3) Brazilian wax 8 oz., crude glycerine 14 oz., hard white curd soap 6 lb., Bismarck brown 4 oz., turpentine 3 pints, water ½ gal. Shred the wax and soap and dissolve in the turpentine and water (on a water bath, not directly on the fire), stir in the other ingredients.

(4) ½ lb. yellow wax, finely shredded, turpentine 1 pint. Dissolve the wax in the turpentine over a water bath. Dissolve ½ lb. hard white soap in a pint of boiling water. Mix the two solutions while they are hot, then add a little oxalic acid and liquid annatto.

(5) A white paste for brown or light coloured leather boots. Obtain a white glazing ball from a shoemaker (cost ½*d.*) and soften this down in turpentine. Add ¼ lb. best white-wax, broken small, and let the turpentine be sufficient to just cover the two. These ingredients should be in an earthenware jar, Place the jar on the hob, well away from the fire, and, when all are melted, mix well and the paste is ready for use.

Wax Boot-Polish.—(1) Beeswax 2 oz., beef suet 4 oz., rosin 1 oz., neat's-foot oil 2 oz., lampblack 1 oz.; melt together. (2) Yellow wax 8 oz., turpentine 12 oz., powdered indigo 4 dr., drop black 2 oz., paste Prussian blue 1 oz., oil cassia 2 dr. Melt the wax in a water-bath by aid of heat, and add to it 8 oz. of the turpentine. Put the other ingredients into an old mortar, and rub with the remaining 4 oz. into a smooth paste; add to this the wax solution, and stir until it thickens. Apply a small quantity with a stiff brush, and polish with a soft brush. (3) Carnauba wax 12 oz., dissolve by gentle heat in 2¾ pints of turpentine; add 3 oz. of vegetable black; mix well, and add ½ oz. soap, dissolved in 8 oz. water. Mix thoroughly, and use as usual.

To Black Tan Boots and leave a Glossy Polish.—(1) Dissolve about two tablespoonfuls of washing soda in warm water, and apply this to the leather with a piece of flannel. Allow this to dry then apply cobbler's ink with a hard brush, allowing this also to dry well into the leather. The boots will then be ready to clean, and will be found to have a fine glossy appearance, which will remain as long as the boots last. (2) Get a fairly large potato, cut into two or three pieces, and thoroughly rub juice of same into boots. When perfectly dry, the boots will be found to take the blacking excellently, and produce a lasting polish.

Dubbin.—(1) Get 5 lb. best tallow, 1 lb. best beeswax, cut up small, and let melt slowly. When thoroughly melted, add a good tablespoonful of Norway tar. Allow to cool, and when wanted, cut a bit out, and melt and rub well into the boots. It keeps the leather soft and pliable, and keeps out all wet. (2) Carnauba wax 2½ lb., black rosin 4¾ lb., vegetable black 1 lb., neat's-foot oil, tallow oil, and linseed-oil, 1 gallon of each. The foregoing soften and preserve the leather as well as making the boots waterproof. (3) Brown, liquid. Carnauba wax 4 lb., pale rosin 3¾ lb., phosphine substitute ½ oz., linseed-oil 1¼ gal., tallow oil 1 gal., neat's-foot oil 1 gal. Shred the wax and crush the rosin fine. Boil these in the oils. Lastly add the phosphine colouring matter.

Harness Blacking is not made in the same way as boot blacking. The following are some of the methods of preparing the former kind :—

(1) Glue or gelatine, 4 oz. ; gum arabic, 3 oz. ; water, ¾ pint. Dissolve by heat, and add of treacle, 7 oz. ; finely powdered animal charcoal, 5 oz. ; and then gently evaporate until the compound is of the proper consistence when cold, stirring all the time. It must be kept corked.

(2) Mutton suet, 2 oz. ; beeswax, 6 oz. ; melt them, and add sugar candy, 6 oz. ; soft soap, 2 oz. ; lampblack, 2½ oz. ; finely powdered indigo, ½ oz. When thoroughly intermixed, add oil of turpentine, ¼ pint.

(3) Beeswax, 1 lb. ; animal charcoal, ½ lb. ; Prussian blue, 1 oz. ; ground in linseed-oil, 2 oz. ; oil of turpentine, 3 oz. ; copal varnish, 1 oz. Mix them well, and form the mass into cakes while it is still warm.

(4) Add to No. 3, while still warm, soft soap, 4 oz. ; oil of turpentine, 6 oz. ; put into pots or tins while warm.

(5) Isinglass, ¼ oz. ; finely powdered indigo, ¼ oz. ; soft soap, 4 oz. ; glue, 5 oz. ; logwood, 4 oz. ; vinegar, 2 pints ; ground animal charcoal, ½ oz. ; beeswax, 1 oz. Infuse the logwood in the vinegar for some time with gentle heat, and when the colour is thoroughly extracted strain it, and add the other ingredients. Boil till the glue is dissolved, then store in stoneware or glass jars. Said to be very useful for army harness.

(6) Melt 4 oz. mutton suet with 12 oz. beeswax, 12 oz. sugar candy, 4 oz. soft soap dissolved in water, and 2 oz. finely powdered indigo. When melted and well mixed, add ½ pint turpentine. Lay it on with a sponge, and polish with a brush. A good blacking for working harness, which should be cleaned and polished with it at least once a week.

(7) 3 sticks black sealing-wax dissolved in ½ pint alcohol, and applied with a sponge, or lac dissolved in alcohol, and coloured with lampblack, answers the same purpose. This is intended for carriage harness ; it is quick drying, and hard and liable to crack the leather, so should be applied as seldom as possible.

(8) A good blacking consists of : Hogs' lard, 4 oz. ; neat's-foot oil, 16 oz. ; yellow wax, 4 oz. ; animal charcoal, 20 oz. ; brown sugar, 16 oz. ; water, 16 oz. Heat the whole to boiling, then stir it until it becomes cool enough for handling, and roll it into balls about 2 in. in diameter.

(9) Soften 2 lb. glue in 1 pint water ; dissolve 2 lb. soap (Castile is the best, but dearest) in 1 pint warm water ; after the glue has become thoroughly soaked, cook it in a glue-pot, and then turn it into a larger pot ; place this over a strong fire, and pour in the soap water, slowly stirring till all is well mixed ; then add ½ lb. yellow wax cut into slices ; let the mass boil till the

wax melts, then add ½ pint neat's-foot oil and sufficient lampblack to impart a colour; let it boil a few minutes and it will be fit for use.

(10) When harness has become soiled it can be restored by the use of the following French blacking: Stearine, 4½ lb.; turpentine, 6¾ lb.; animal charcoal, 3 oz. The stearine is first beaten into thin sheets with a mallet, then mixed with the turpentine, and heated in a water bath, during which time it must be stirred continually. The colouring matter is added when the mass has become thoroughly heated. It is thrown into another pot, and stirred until cool and thick; if not stirred, it will crystallise, and the parts will separate. When used, it will require warming; it should be rubbed on the leather with a cloth, using very little at a time, and making a very thin coat. When partially dry, it is rubbed with a silk cloth, and will then give a polish equal to that of newly varnished leather, without injuring it in any way.

(11) 2 oz. shellac, 3 pints alcohol, 14½ pints fish oil, 19 pints West Virginia oil, 1 lb. lampblack, 1 pint spirits of turpentine, 9 pints coal oil; the two first are combined, then the third is added, and all the others are well mixed.

(12) Heat together over a slow fire, 2 oz. white wax and 3 oz. turpentine; when the wax is dissolved, add 1 oz. ivory black and 1 dr. indigo, thoroughly pulverised and mixed; stir the mixture until cold. Apply with a cloth, and polish with a shoe-brush.

(13) An excellent oil for farm and team harness is made of beef tallow and neat's-foot oil as follows: Melt 3 lb. pure tallow, but do not heat it up to a boil; then pour in gradually 1 lb. neat's-foot oil, and stir until the mass is cold; if properly stirred, the two articles will become thoroughly amalgamated, and the grease will be smooth and soft; if not well stirred, the tallow will granulate, and show fine white specks when cold. The addition of a little bone-black will improve this oil for general use.

(14) Melt together 8 oz. beef suet, 2 oz. neat's-foot oil, 2 oz. white wax, and 2 oz. pulverised gum arabic; add 1 gill of turpentine, and sufficient bone-black to give the whole a good colour; stir until thoroughly mixed, remove from the fire, continue to stir until cold, then roll into balls. To apply, warm the ball, rub it on the leather, and polish with a woollen cloth.

(15) English ball blacking for harness is composed of 1 oz. lard, 1 oz. beeswax, 8 oz. ivory black, 8 oz. sugar, 4 oz. linseed-oil, and 2 or 3 oz. water.

(16) Another kind is made of 2 oz. hogs' lard, 8 oz. best neat's-foot oil, 2 oz. beeswax, 10 oz. ivory black, and 8 oz. water. Heat the whole to a boil, remove from the fire, stir until sufficiently cool, and form into balls about 2 in. in diameter.

(17) A third description is made of 2 oz. each ivory black, copperas, and neat's-foot oil, 4 oz. brown sugar, 4 oz. soft water, and 1 oz. gum tragacanth; boil until the water has evaporated, stir until cold, then roll into balls or mould into cakes.

(18) A fourth is made of ½ lb. beeswax, 4 oz. ivory black, 2 oz. Prussian blue, 2 oz. spirits of turpentine, and 1 oz. copal varnish; melt the wax, stir in the other ingredients, and, when cool, roll into balls.

(19) Still another famous harness and saddlery blacking is made of ¼ oz. isinglass, ¼ oz. indigo, 4 oz. logwood, 2 oz. soft soap, 4 oz. glue, and 1 pint vinegar; the whole is warmed, mixed, strained, allowed to cool, and is then ready for use.

(20) Mix 1 oz. indigo, 1 lb. extract of logwood, 1 oz. softened glue, and 8 oz. crown soap (common soft soap can be used if the other cannot be had) in 2 qt. vinegar; place the mass over a slow fire, and stir until thoroughly mixed. Apply with a soft brush, and use a harder one for polishing.

(21) *Restoring Leather-covered Mountings.*—Melt 3 parts white wax, then add 1 of gum copal, dissolved in linseed-oil, and 1 of ivory black; allow the mass to boil for 5 minutes, remove

it from the fire, stir until cold, and roll up into balls.

(22) Another: to 1½ lb. lampblack add 1 gal. pure neat's-foot oil, and 1 qt. vinegar black; allow it to stand 24 hours, and it will be ready for use.

(23) *Crown Soap Black.*—Dissolve, over a slow fire, 1 lb. beeswax, 1 lb. crown soap, 3 oz. indigo, 4 oz. ivory black, and ½ pint oil of turpentine; as soon as dissolved, remove from the fire, and stir until cold.

(24) Take 6 oz. turpentine, 3 oz. beeswax, 1½ oz. ivory black, ½ oz. indigo blue, ½ oz. ink. Cut the beeswax fine, pour the turpentine on it, let it stand covered 5 or 6 hours, and mix well together; to be kept covered.

(25) Digest 12 parts shellac, 5 white turpentine, 2 gum sandarach, 1 lampblack, with 4 of spirits of turpentine, and 96 of alcohol.

(26) *For Brown Harness.*—The following two recipes have been used by the writer for a long period and will be found economical and satisfactory. Take 3 lb. of beeswax, 1 lb. of lard, ¼ lb. of neat's-foot oil, 1 lb. of turpentine, and sufficient dragon's-blood to colour to the shade desired. Melt the wax and the lard together, add the oil, and stir well; allow to cool, then mix in the turpentine. Before the mixture cools too much add the colouring matter, stirring well in. Apply the polish to the leather, brush well, and finish with a linen rag.

(27) To make a cream for brown leather, procure 2 lb. of best beeswax, ¼ lb. of pearlash, 1 lb. of best yellow soap, 6 lb. of water, 4 lb. of turpentine, and ¼ lb. of methylated spirit. Put the pearlash into the water and place over a fire to boil, and into this scrape the wax and soap; let the mixture again boil till thoroughly amalgamated, stir well until homogeneous. Allow to cool down somewhat, then add the turpentine, and lastly the spirit; mix all well together and thin with water if necessary. Rub the cream on the leather, dry polish with a brush, and finish with rag. Both the above are good nourishing applications, as well as good polishers.

(28) *For Russet Leather.*—Mix together 1 part palm oil and 3 parts common soap, and heat up to 100° F.; then add 4 parts oleic acid, and 1¾ of tanning solution, containing at least $\frac{1}{16}$ of tannic acid (all parts by weight), and stir until cold. This is recommended as a valuable grease for russet leather, and as a preventative of gumming.

(29) Cordova Wax.—Mix together 1¼ pint red acid (chromic), 1 pint beer, 1 gill thick glue, 2 oz. ivory black, and 1 dr. indigo; boil for ½ hour and apply with a sponge.

Liquid blacking is usually filled into bottles closed by corks. Paste blacking is now more often put up in flat tins, though there is still a large demand for the commoner qualities wrapped in waterproof paper. The latter is generally prepared by steeping the paper first in boiled linseed-oil, pressing, then hanging up to dry for 18 hours to a week. The following is an improved way of making a waterproof paper of superior quality, thinner, but equally strong, and capable of drying in less than a minute. The paper is steeped in a melted or fluid composition, consisting of paraffin wax, or hard tallow, in combination with crude or other turpentine, in the proportions of two to one. It is then immediately pressed, and the surplus composition is removed by passing it between rollers heated by steam. By using paper in endless sheets, the whole process might be made continuous, the paper being finished for use or storing by the time it leaves the rollers.

It is obvious that the manufacture of blacking requires neither skill nor capital. It may be conducted on almost any scale according to the demand.

* * *

BLEACHING.

(*See also* CLEANSING. There will also be found many other bleaching recipes embodied in the description of processes relating to the manufacture or preparation of various materials and substances. Linseed-oil and varnish may be mentioned as examples. For these *see* Index.)

BLEACHING may be described as the art of whitening or decolorising substances. The following are subjects not dealt with in other parts of this work :—

Albumen.—Leon Maret is the inventor of a curious process of bleaching blood-albumen by the electric light. By a long exposure to this, the colouring matter of the albumen is said to be destroyed gradually, until a product is obtained which is almost as white as egg-albumen. The usual process for obtaining blood-albumen is followed, and when the albumen is separated from the blood, it is exposed to the electric light, either while still in the liquid state or when dried. By means of lenses, or reflectors, the light is projected from the lamps on the albumen. If the latter is in the liquid state, the exposure to the light is done in the drying stoves, where the albumen is placed in shallow trays, the light being projected on the surface. These trays are made of glass, in order to allow the rays to penetrate into the interior; 24 hours' exposure is said to produce complete decolorisation.

Animal Fibres.—(1) Animal fibres which have to be bleached with peroxide of hydrogen must first be subjected to a treatment which renders them fit to be perfectly soaked with the solution. All fat, suet, and uncleanliness must be taken off. The best methods of doing this are soap baths and 3 to 5 per cent. carbonate of ammonia solutions, and in some cases other solvents, such as sulphide of carbon, benzine, ether, etc. For bleaching, the solution of peroxide of hydrogen, which is 3 per cent. by weight, or 10 per cent. by volume, is neutralised by means of a few drops of ammonia, and then used as a bleaching bath. If the bleaching has to be continuous, it is recommended to use several baths of different strengths, in which the goods are passed, beginning from the weaker bath. The light has to be kept off, and the temperature must not rise above 77° F. (25° C.). Another method is to dip the cleaned goods in the solution of peroxide of hydrogen, in which they are left until soaked, and are then exposed to dry in a draught, the temperature not to rise above 68° F. (20° C.). The bleaching takes place energetically by the evaporation of the water and subsequent concentration of the peroxide.

(2) The use of bisulphite of soda has proved to be superior to the old method of bleaching in sulphur ovens. The process with the bisulphite requires 6 to 8 hours, and therefore the sulphur bleachers have been slow to adopt it, the sulphur method occupying less time. The following suggestions are made: Prepare an ordinary dilute solution of soda bisulphite, with the necessary quantity of sulphuric acid, and use the following apparatus, which is on the same principle as that used in the cotton bleaching process in the Barlow kiers. A large cask, with sufficient strength to withstand some steam pressure, is previously filled with thoroughly moistened fibre and tightly pressed in. The prepared solution of soda bisulphite and sulphuric acid, not marking more than 7° Tw., is allowed to enter and soak through the whole lot of fibre; after 5 or 10 minutes' contact, steam is turned on, which presses the solution through the perforated pipe in the centre of the cask and out of the apparatus. The fibre is taken out and aired, by which the bleaching process will not be interrupted; and when nearly dry it is entered a second time. Probably 3 or 4 manipulations would suffice to finish the bleaching, and would not occupy more than 2 hours. The waste liquor

is collected, and made up to the first strength for re-use. ('Textile Colourist.')

Bones, Skulls, and Anatomical Specimens.—These may be boiled or steamed until the flesh and cartilage will come away by scraping with blunt wooden scrapers, but this method is apt to make the bones greasy looking. Better results are obtained by letting the specimens remain in cold water until the flesh decomposes, and can be scraped off (with wooden instruments), but this is not an agreeable method. When either is done, and the bones cleaned, the bleaching is effected by soaking them in a solution of 3 oz. chloride of lime to 1 gal. of water for about six hours. For removing dirt bones may be scrubbed with strong soda and soap, solution, and, if necesary, a penknife may be used for scraping necessary parts, if proper care is used. If the chloride of lime bleaching is not found sufficient, then air bleaching may be resorted to, to complete the work. Wet the specimens each morning, and expose them to wind and sun, this being as effective as anything in bleaching bone material.

Bleacher's Ink.—This is an ink that can be used for marking cotton and other goods, as it will withstand chlorine. Thin 4 oz. of gas tar with 1 oz. of benzole, dissolve ½ oz. of asphaltum in 1 oz. turpentine. Mix all together, and grind in a mortar or mill; it is then fit for use.

Coral.—First well wash in very dilute hydrochloric acid (1 part B. P. acid to 30 water); then well rinse in water, then put into some chloride of lime and water.

Cotton.—The bleaching of cotton goods has become a very large industry, and the processes involved are too numerous and complicated to admit of lucid description here. The reader should refer to the complete article on the subject in Spon's 'Encylopædia.'

Esparto.—Esparto pulp for paper-making is bleached in the "poacher" by means of a solution of bleaching powder. Some manufacturers hasten the process by adding a little hydrochloric or sulphuric acid; others steam-heat the mass to about 90° F. (32° C.); others put in a small quantity of soda bicarbonate. The quantity of bleaching-powder necessary depends on the quality of the grass and the degree of boiling: 12 lb. per cwt. of esparto is a fair average. After being about 2 hours in the poacher, the almost white pulp is drained in large chests for 8 hours or longer, exposed to the action of light, and finally pressed to remove the excess of liquor.

Fats and Grease.—A common plan is to provide two vats, one above the other, the upper one being lined with sheet lead and provided with an open steam coil and stirring gear, the lower one with open steam coil alone. Run the hot fluid fat into the top vat, have some sulphuric acid slightly diluted with water, and add one or two pounds of this to every 100 pounds of fat and stir well. As soon as thoroughly stirred, turn on steam, and continue stirring. Now run the whole into the lower vat, add hot water and turn on steam. When the whole is well steamed let it stand until the water collects at the bottom from which it is drawn off. Hot water is again added and steam applied and the process repeated; this being done about three times to thoroughly wash the fat. After the water is separated and drawn off the last time, the fat is filtered through a bag.

Feathers.—(1) The feathers are put into a bath of permanganate of potash, containing 4 to 5 parts permanganate to 1000 of water; a solution of sulphate of magnesia of the same strength is added, and it is heated 140° F. (60° C.) at the most. The feathers previously washed, are put into this bath, then taken out, rinsed, and passed through weak sulphuric acid at about 1½° to 3° Tw. (2) It is also possible to bleach the feathers in a bath of 1 part barium peroxide in 100 of water at 86° F. (30° C.). Leave 48 hours in this solution, wash, pass through weak acid bath, and wash. (3) Feathers may be bleached by exposure to the vapour of burning sulphur (sulphurous acid) in a moist atmosphere, but it is usually necessary to remove the oily matters from them before they can be satisfactorily so bleached. This may be accomplished by immersing them for a short time in naphtha or benzine, rinsing in a second vessel of the same, and thoroughly drying by exposure to the air. This treatment does not injure the feathers. (4) Peroxide of hydrogen is largely employed. The advantage it offers is the oxidation and complete disappearance of the colour, without spoiling the structure of the feather. The feathers are first dipped in a solution of 1 to 2 per cent. carbonate of ammonia in water, in which they are slightly agitated, and left for about 12 hours at 68° F. (20° C.). The feathers are then taken through a tepid white soap bath, and well washed in water which is free of lime. The treatment with benzine and ether also gives good results. The bleaching bath is neutralised. Wood or metal vessels are not recommended for the baths, and it is better to use earthenware vessels. When bleached, the feathers are dried slowly at a low temperature in a draught, and are often beaten. A good result is obtained by dipping the bleached feathers in alcohol, which gives them a finer appearance. The succeeding operations are the same as by other processes. This method of bleaching feathers is said to prove superior to all others. Black spots are perfectly bleached after being exposed for some time. (5) The feathers are placed for 3 to 4 hours in a tepid dilute solution of bichromate of potash, to which some nitric acid has been cautiously added. After this lapse of time, the feathers will have assumed a greenish hue, owing to the chromium oxide precipitated; to remove this, they are placed in a dilute solution of sulphurous acid in water, when they become perfectly white. Care must be taken that the bichromate bath is not too strong, and especially that excess of nitric acid be avoided. (6) The objection attending the use of acid or alkaline baths is that they alter the texture of certain feathers. In Roy's process, the feathers are first soaped, and, after thorough washing, subjected to the action of ozone. By a succession of immersions in water and treatments with the gas, bleaching is effected without injury to the feathers. (7) Viol et Duplot's method rests on the fact that the feathers immersed in resinous essences (e. g. turpentines, oils of lavender, thyme, etc.) or bituminous hydrocarbons, are bleached under the influence of light or heat. The feathers are kept in the vessels a longer or shorter time, according to degree of whiteness desired (generally about 3 or 4 weeks), at a temperature of 86° F. (30° C.), and exposed to the light. (8) The common method is as follows. The feathers are first washed in soap lather, well rubbed with the hands, and passed through clean scalding water. For white feathers, they are first exposed to the action of sun and dew for about a fortnight, washed in a hot bath containing Spanish white (the softest and purest white chalk), and passed through 3 clean waters; next they are blued by a rapid passage through a cold bath containing indigo; after this, they are sulphured by suspension in a sulphuring stove; and are finally hung upon cords to dry, being occasionally shaken to open the fibres. (9) Scouring and bleaching are two distinct operations, the former tending to remove from the material all fatty substances, while the latter consists in rendering the feathers perfectly white, after having been cleansed from their fatty contents. According to quality, the first washing in soap is done at 100° to 122° F., the bath to be prepared in the proportion of 500 parts by weight of white Marseilles soap for

600 of water, and well beaten up into a lather. Lay down the feathers and rub them well by hand until the bath is exhausted and has lost its detergent power. Then let it out, and repeat the operation with a fresh bath of the same composition; then remove the soap by rinsing in 2 or 3 waters at 100° F. Prepare a cold bath of 45 to 62 gr. of bioxalate of potash to 5 qt. of water, lay down the feathers for 15 or 20 minutes, lift and rinse in cold water. After passing them 3 or 4 times through the cold water, the feathers are to be blued. For this purpose add to a fresh bath of cold water so much solution of (methyl) aniline violet as will give the water a faint tint; open the feathers well and agitate them in the bath until they also have assumed the tint; then squeeze them out in a clean white piece of cloth (muslin), and pass through a pretty thick solution of raw starch (8 oz. to 4 qt. water unboiled), squeeze out again, open them by passing the hand lightly over the stem, and dry either in a warm place, or preferably in the air, shaking them repeatedly while drying in order to perfectly open the fibres. Finally beat out the remaining starch either by hand or by means of a soft brush. (10) The peroxide of hydrogen process is undoubtedly better than using sulphurous acid, for though it costs more, it is less likely to injure the feathers if unskilfully done. For the peroxide, first soak the goods for a few hours in a solution of 3 oz. of carbonate of ammonia to 1 gal. of water, then wash in warm soap and water, using Castile or white curd soap. Pass through clean soft water, and they are ready for the peroxide bath. Make a solution of 1 part hydrogen peroxide to 10 of water, and immerse the feathers in this. Take out, wash in clean water, dry slowly and curl. To get a pure white the feathers may go through a warm soap bath having a little blue powder in it. Dyeing may be done as soon as the bleaching is completed. Dyeing dark colours is done without bleaching, the feathers only being softened with the carbonate of ammonia and washing.

Glue.—*See* Glue Manufacture.

Guttapercha.—Dissolve in 20 times its weight of boiling benzol, add $\frac{1}{10}$ part plaster of very good quality, and agitate occasionally. By reposing for 2 days, the plaster is deposited and carries with it all the impurities not soluble in benzol. The clear decanted liquid is introduced by small portions into twice its volume of 90 per cent. alcohol, agitating continually. During this operation the guttapercha is precipitated as a pasty, perfectly white mass. The subsequent desiccation of the guttapercha requires several weeks' exposure to the air, but is accelerated by trituration in a mortar.

Hair.—(1) The hair is left for 12 hours in a solution of 3 parts carbonate of ammonia in 100 water at 86° F. (30° C.), then washed, washed again in soap, and completely scoured with another solution of carbonate of ammonia. The hair is afterwards dipped in the solution of peroxide of hydrogen, which has been completely neutralised with ammonia. The hair is either left in the bath until sufficiently bleached, or it is taken out, dried by ordinary temperature, and retaken through the bath. To ascertain if the baths have become useless for further work, a few drops of permanganate of potash are added, and if the bath takes a permanent red colour its bleaching power is exhausted. Black hair is not bleached to perfection; it can only be bleached to light gold-yellow. The hair is then washed in water, and can be treated with alcohol. Warm solution and drying in hot air are to be avoided.

(2) A recipe stated to bleach human hair white instead of blonde or yellow. Mix 1 lb. hydrogen peroxide with 1 oz. ammonia; mix 4 oz. hydrogen peroxide with 1 oz. cream of tartar dissolved in 1 oz. soda. Blend the two solutions, and steep 1 lb. of the hair in it for 3 hours. Then wash in clean water with "soapine" in a bath

of pottery or clay, and thoroughly dry. Repeat the process 15 or 16 times; but thoroughly mix and shake up the hair after the 12th and every succeeding time. Finally, draw the hair through a solution of blue aniline and alcohol.

(3) A hot dilute solution of nitric acid is most effectual. Brown hair, when carefully treated, is turned the most brilliant golden, resembling golden spun glass. The method employed is to put the hair in a porcelain dish with dilute NO_2 HO (about 1 part strong acid to 10 of water), then gradually heat, and, as soon as the required shade is obtained, take out and wash. If the acid is too strong, or the heat too great, the fibre of the hair is spoiled. Dark-brown hair acquires generally a reddish colour, and black hair will turn nearly white.

Horsehair. — If a pure white horsehair is required, the hair must be white to start with, as yellow or grey horsehair cannot be made pure white. First thoroughly wash in hot soap and water, then rinse well in clean hot water. Allow to soak about 12 hours in a solution of peroxide of hydrogen made alkaline by ammonia. Lastly wash in clean water, and dry slowly.

Ivory.—(*a*) Antique works in ivory that have become discoloured may be brought to a pure whiteness by exposing them to the sun under glasses. It is the particular property of ivory to resist the action of the sun's rays, when it is under glass; but when deprived of this protection, to become covered with a multitude of minute cracks. Many antique pieces of sculpture in ivory may be seen, which, although tolerably white, are, at the same time, defaced by numerous cracks; this defect cannot be remedied; but in order to conceal it, the dust may be removed by brushing the work with warm water and soap, and afterwards placing it under glass. Antique works in ivory that have become discoloured, may be rubbed with pumice and water, and while yet wet placed under glasses. They should be daily exposed to the action of the sun, and be turned from time to time, that they may become equally bleached; if the brown colour be deeper on one side than the other, that side will, of course, be for the longest time exposed to the sun.

(*b*) Immerse for a short time in water containing a little sulphuric acid, chloride of lime, or chlorine.

(*c*) Expose it in the moist state to the fumes of burning sulphur, largely diluted with air.

(*d*) Ink stains may be removed by repeatedly using a solution of quadroxalate of potash in water.

(*e*) Ivory that has become yellow by exposure can be whitened by washing in a solution composed of 1 oz. of nitric acid and 10 oz. of soft water; apply with a rough brush; cleanse thoroughly in clean water.

(*f*) Peroxide of hydrogen is used in Sheffield to bleach the inferior ivory for knife handles. The mode of procedure is as follows: Place, say, 2 qt. of the liquid in a stone pot, adding 4 oz. liq. ammon. fort. (880°), immerse the handles, and put over a common shop stove for 24 to 36 hours; the handles are then taken out and gradually dried in the air, not too quickly, or they would split. The deep colour of the ivory is removed, and a beautiful pearly white ivory results when polished. The ivory is previously treated with a solution of common soda, to get rid of greasy matter, and open the pores.

(*g*) Spirit of turpentine is very efficacious in removing the disagreeable odour and fatty emanations of bones or ivory, while it leaves them beautifully bleached. The articles should be exposed in the fluid for 3 or 4 days in the sun, or a little longer if in the shade. They should rest upon strips of zinc, so as to be a fraction of an inch above the bottom of the glass vessel employed. The turpentine acts as an oxidizing agent, and the product of the combustion is an acid liquor which sinks to the bottom, and strongly attacks the bones if they be allowed to touch it. The action of the turpentine is not confined to bones and ivory, but extends to wood of various varieties, especially beech, maple, elm, and cork.

Jute.—(1) The question of bleaching jute without injury has been studied for a long time. All bleachers have boasted of being able to bleach it as well as, or even better, than linen and hemp, but all have found that the bleaching was more apparent than real, and that the goods, after lying some months in the warehouse, turned from white to yellow. Several manufacturers, for want of anything better, have been content with giving the jute a cream shade, and for this purpose they make use of rollers over which the hanks are hung, so that their lower ends dip into a weak chloride bath, very slightly warmed, for 30, 40, or 50 minutes. The hanks are then passed into water, pressed and dried in the air.

The treatment of jute by complete submersion, air being excluded, is the safest. Treatment on the roller with the intervention of air is the most dangerous. The reason of this is that in the former case the bleaching is a slow oxidation, whilst in the latter it is the result of the rapid and energetic action of hypochlorous acid. It has been tried, but without much success, to use silicate of soda and chloride of soda; chloride of lime is preferable. But to get good white it is necessary to steep the jute alternately in a soap-bath and in a solution of chloride of lime. The following are directions for a so-called cream shade: Immerse in a weak and luke-warm soap-bath for about 10 minutes; after draining, immerse for 40 minutes at most, in a bath of chloride of lime, not marking more than ½° on the chlorimeter.

The duration of the immersion may be variable, the quality of the jute and the shade which it is wished to obtain being the best guides. As for whites more decided than cream shades, they are produced in the same manner, but the duration of the steepings in the soap-lye and the chloride of lime is shortened, and these operations are repeated several times in succession. Whatever may be the shade at which the process is brought to an end, it is well to finish with two washings, the one in luke-warm and the other in cold water. The jute is then drained and dried at as low a temperature as possible. It is recommended that during the steeping process the jute should be regularly but gently agitated, taking care not to bring it above the surface of the liquid.

(2) According to Scheurer, chloride of lime was at one time considered suitable for jute bleaching, but it was soon found that this reagent made the yarn hard and brittle, likewise removing, along with a portion of its solidity, that silky brightness which constitutes one of its principal merits. Hypochlorite of soda, on the contrary, by reason of the more rapid and uniform oxidation which takes place, can be employed at a high degree of concentration without the resistance of the fibre being impaired. Its action has, however, to be regulated with care, on account of its powerful properties as a reagent. Bleached jute would suffer by being plunged into a concentrated solution of hypochlorite of soda, while such is not the case with jute in the unbleached state, in which the cellulose is protected in the earlier stages of the operation by the incrusting substance. It is the latter portion of the process (specially affecting the purification of the white) which is usually found to affect the solidity of the textile substance under treatment, even when the solution has not been a strong one. Therefore, Scheurer considers that, to save the fibre from the corrosive action of the hypochlorite, it is necessary to diminish the force of the reagent, as the operations succeed

each other, and to preserve a certain relation between the degree of concentration of the oxidizing liquid, and the quantity of the encrusting substance which remains to be destroyed. In this way a satisfactory white is obtained, without prejudice to the textile substance operated upon.

(3) According to a patent taken out by T. G. Young, the jute is first soaked in a solution of a sulphide of an alkali, or alkaline earth, till sufficiently softened. It is then washed and submitted to a bleaching agent composed of a solution of chlorine and an alkali, other than chloride of lime, such as chlorine and soda, until the desired bleaching results are obtained.

Lace.—Lace may be restored to its original whiteness by first ironing it slightly, then folding it and sewing it into a clean linen bag, which is placed for 24 hours in pure olive oil. Afterwards the bag is to be boiled in a solution of soap and water for 15 minutes, then well rinsed in lukewarm water, and finally dipped in water containing a slight proportion of starch. The lace is then to be taken from the bag and stretched on pins to dry.

Leather : Fine goods.—In the preparation of the light tinted fancy book covers, and which are sometimes a pinkish white, the leather is immersed in benzine for an hour, for the colouring agents in leather, ferric oleate and tannate are soluble in benzine. After one hour's immersion remove the leather and then evaporate the benzine it carries by gentle heat over a water bath. The leather is then treated with liquid sulphurous acid, or javelle water, or peroxide of hydrogen with ammonia. Care must be used in drying.

Linen.—The same remarks apply here as to cotton bleaching. (*See* Spons' 'Encyclopædia.')

Oils.—Many plans of decolorising oils are in vogue: (*a*) Exposure to sunlight in large white glass bottles; the oil soon becomes colourless, but acquires an almost rancid flavour. (*b*) Agitation with 2 per cent. of a solution of permanganate of potash; bleaches effectually, but also leaves a bad flavour. (*c*) The oil is first agitated with water containing gum, and to the emulsion thus formed, is added coarsely crushed wood charcoal; the whole is then slowly warmed to a degree not reaching 212° F. (100° C.), and when cold, the oil is dissolved out by ether or petroleum-spirit, and the latter is recovered by distillation; the result is good. (*d*) A process much recommended is to pass nitrous acid gas through the oil. (*e*) The oil (500 parts) is clarified by addition of 50 parts of China-clay and 50 of water. (*f*) In some cases, it is found advisable to use the coagulation of albumen in clarifying oils. The oil to be treated is mixed by agitation at the ordinary air-temperature with a weak solution of albumen in water. The whole is then gradually heated, most conveniently by steam, and when hot enough to coagulate the albumen, this latter collects in clots, enclosing particles of impurity; after the lapse of sufficient time, these clots subside, and the clarified oil is removed by decantation. The process is analogous to that of the refining of syrups by serum of blood.

Many oils are partially or completely decolorised by filtration through, or agitation with, freshly-burnt animal-charcoal (bone-black). The apparatus for filtering is similar to that employed in sugar-refineries, and consists essentially of tall wrought-iron cylinders filled with bone-black, and provided with a steam-jacket to control their temperature. When the charcoal ceases to decolorise, it should be treated with some solvent (bisulphide of carbon, or petroleum-spirit) to remove the oil, before it is revivified by calcination.

Most processes for the bleaching of oils depend upon the oxidization of the colouring matter by some suitable reagent, chiefly evolving nascent oxygen in some form. There are, however, instances known in which the colour is destroyed by a reducing agent such as sulphurous acid, in an aqueous solution, as gas, or arising from the decompositon of an alkaline hyposulphite (e. g. that of soda) by a strong mineral acid. It may be laid down as a general rule that oils which have been burnt or charred by any previous process cannot be satisfactorily bleached. Experiment alone can determine the particular process best suited to any given oil, having regard to the purpose for which it is to be used. The utmost care is required in using any oxidation process for fats intended to be converted into soap, since if the fat be oxidized in any perceptible degree, as well as the colouring matter (i. e. if too much of the bleaching reagent be used), the resulting soap will often be worse in colour than if the fat had not been bleached at all.

Palm-oil and tallow are the two chief fats bleached by the soap-maker. Both may be bleached by pumping air into them in finely divided streams, while they are kept at about 180° to 200° F. (82° to 93° C.). The colour of tallow may also be removed by boiling upon a solution of chloride of lime, or of chlorate of potash, to which a strong mineral acid has been added. No more potassic chlorate than 0·1 per cent. on the tallow should be employed.

Experiment has shown that the colour of palm-oil may be quite destroyed by heat. To effect this, the oil may be kept for some hours at about 260° F. (127° C.), or it may be put into a closed, horizontal, iron cylinder, and heated by a fire beneath up to about 464° F. (240° C.), at which temperature the colour is destroyed. This process gives rise to most offensive vapours, especially acrolein, and necessitates the conduct of operations in a closed vessel, with suitable means of condensing the vapours and rendering them innocuous.

Palm-oil may also be very suitably bleached by bichromate of potash and hydrochloric acid (Watts' process). The oil is made as free as possible from impurities, and, at about 120°–130° F. (49° to 54° C.), is agitated with a strong solution of bichromate of potash, containing about 1 lb. of the salt to every 100 lb. of oil. To this is added enough hydrochloric acid to form sesquichloride of chromium with all the chromium in the bichromate of potash, the quantity of liquid acid necessary of course varying with the amount of real acid contained in it. A slight excess of acid is rather an advantage than otherwise. The process occupies about an hour, after which, subsidence removes most of the chemicals, while subsequent agitation with hot water renders the oil quite pure enough for the soap-copper. (Spons' 'Encyclopædia.')

Paper.—(*a*) For bleaching rags, and other materials from which paper is at first fabricated, rags, when grey or coloured, are to be separated and ground in the paper-mill in the usual way till brought to a sort of uniform consistence, having been previously macerated according to their quantity and tenacity. The mass is then treated with an alkaline lye. It is next treated with a solution of chloride of lime. If this immersion do not produce the desired effect, which does not often happen if the colours are tenacious, such as red and blue, let the treatment with the alkaline lye be repeated, and follow it with another bath of the chlorine preparation. Then sour the whole in a bath of sulphuric acid, much diluted and cold, for when hot its action will be less effectual. Water is then to be run upon it till it comes off without colour or indication of acidity. Black is the most easily discharged colour, and will seldom require being treated with lye or steep of sulphuric acid, one bath of alkali and another of chloride of lime being sufficient to produce a good white.

(*b*) *Old printed or written paper is*

first sorted according to its quality, and all the yellow edges cut off with a bookbinder's plane. 1 cwt. of this paper is put sheet by sheet into vats sufficiently capacious with 500 qt. of hot water. The whole is stirred for about an hour, and as much water gradually added as will rise about 3 in. above the paper, and left to macerate for 4 or 5 hours. It is then ground coarsely in the mill and boiled in water for about an hour, taking care to add before it begins to boil, 13 qt. of caustic alkaline lye. After boiling it is macerated in the lye for 12 hours, when it is pressed, and, if sufficiently white, made into paper.

(*c*) Paper which has been very imperfectly bleached may be rendered thoroughly white by pouring upon it in succession, as dilute solutions, 3½ parts alum, 1 part chloride of barium, a little free hydrochloric acid, and ⅛ part calcined chalk—stirring well during the operation. The fibres of the paper become firmly coated with the brilliant white sulphate of baryta which is formed. (*See also* Cleansing.)

Paper-pulp.—(*a*) The washed substances are put into a weak bath containing 6¼ to 8 lb. bleaching powder per 22 gal.; after 6 to 12 hours they are washed and boiled for 2 to 4 hours with carbonate of soda (1 oz. per gal.). If the fibres are very hard, they are treated with sulphuric acid (¼ oz. per gal.), and well drained before boiling with the soda. Finally they are placed in a bath of 6¼ to 8¼ lb. of bleaching powder and 1¾ lb. of soda per 22 gal. for 4 to 6 hours. (*b*) The fibres are passed through an alkaline chlorine bath, containing excess of caustic alkali; 5 per cent. is used for linen, cotton, etc., 25 per cent. for jute and other substances difficult to bleach. The temperature should not exceed 122° F. (50° C.). The bath is readily made by adding excess of soda carbonate to chloride of lime.

Paraffin.—The crude paraffin is filtered, and boiled for 2 hours with 5 per cent. of its weight of sodium sulphide and sufficient water. It is allowed to cool, so, that the mass swimming on the top may become compact and be removed; it is then washed with river water, pressed, and afterwards dissolved in 20 per cent. amyl-alcohol, the paraffin being left as a pasty and pliable mass. It must remain for a time, and then be strongly pressed after filtering through bone-black. (De Molon.)

Prints and Printed Books.—Simple immersion in oxygenated muriatic acid, letting the article remain in it, a longer or shorter space of time, according to the strength of the liquor, will be sufficient to whiten an engraving. If it be required to whiten the paper of a bound book, as it is necessary that all the leaves should be moistened by the acid, care must be taken to open the book well, and to make the boards rest on the edge of the vessel, in such a manner that the paper alone shall be dipped in the liquid; the leaves must be separated from each other in order that they may be equally moistened on both sides. The liquid assumes a yellow tint, and the paper becomes white in the same proportion; at the end of two or three hours the book may be taken from the acid liquor, and plunged into pure water with the same care and precaution as recommended in regard to the acid liquor, that the water may touch both sides of each leaf. The water must be renewed every hour, to extract the acid remaining in the paper, and to dissipate the disagreeable smell. Printed paper may also be bleached by sulphuric acid, or by alkaline or soap lyes. (*See also* Cleansing.)

Pulp Cane.—(1) Soak in a solution of chloride of lime, then dip in dilute hydrochloric acid, afterwards soaking in running water or several changes. (2) Soak in an acid solution of soda bisulphite, then steep in dilute hydrochloric acid. A small quantity should be tried first.

Rags.—Gas-bleaching half-stuff is almost indispensable for the coarse linen rags so plentiful in Russia. The half-stuff must contain sufficient moisture, or the outside only will be bleached, and that but indifferently. An effective test of the moisture is to squeeze the stuff between the hands, when, if the pressure causes no escape of water, but leaves the mass with a damp appearance, bleaching may be proceeded with. It is conducted as follows: Put 1600 lb. of the half-stuff loosely into a stone chamber, and lute all apertures. Into the leaden retort, connected with this chamber by leaden pipes, pour 3 pails of water and 66 lb. of common salt; stir thoroughly, add 65 lb. manganese, stir again, and close the retort. Next charge a leaden vessel with 119 lb. oil of vitriol, and let the acid drop into the retort containing the water, salt, and manganese, through a bell-mouthed bent siphon, which admits the vitriol while preventing the escape of gas. The acid should occupy 3 hours in dropping into the retort. Then heat the retort with steam for 7 hours, and allow 2 hours for the gas to escape up the factory chimney. For fine stuff, such as "willowed" rope, 1 hour extra must be allowed for the escape of the gas. The quantities of manganese, salt, and oil of vitriol used for the various "stuffs" are :—

No. 1. (1600 lb. half-stuff): 50 lb. manganese, 50 lb. salt, 80 lb. vitriol.

No. 2. (1600 lb. half-stuff): 60 lb. manganese, 60 lb. salt, 100 lb. vitriol.

No. 3. (1600 lb. half-stuff): 65 lb. manganese, 66 lb. salt, 119 lb. vitriol.

Ropes, for copying paper (1400 lb. half-stuff): 81 lb. manganese, 91 lb. salt, 124 lb. vitriol. (Dunbar.)

For potching half-stuffs previously gas-bleached, the quantities are :—

No. 1. (600 lb. stuff): 15 gal. chlorine at 4½°.

No. 2. (600 lb. stuff): 20 gal. chlorine at 4½°.

No. 3. (500 lb. stuff): 12 gal. chlorine at 5°.

The quantities of half-stuff filled into the potching engine should be uniform. When the engine is filled, wash for some time with a finer wire than is used on the breaker. When thoroughly washed, raise the washer and introduce the bleaching liquor. In the case of vitriol (concentrated sulphuric acid) being used, a small leaden vessel must be placed in such a position that the vitriol will drop into the engine at the rate of 1 lb. in 20 minutes. The vitriol is previously diluted. When the bleaching is finished the stuff is emptied into stone chests fitted with perforated zinc strainers at the bottom and back, and left for a fixed time. (Dunbar.)

Seaweed.—Soak in distilled water for about a day and a night to soften and remove salt, then put it for 12 hours in a solution of 1 part bisulphite of soda to 10 parts of water; at the expiration of this time, mix 1 part of sulphuric acid with 5 parts of water and add 1 part of this to the first solution which has the seaweed in it. Let remain a few hours longer, then soak in several changes of clean water and dry slowly.

Shellac.—(1) By exposure in thin threads to the atmosphere.

(2) 1 lb. of shellac is dissolved in 4 lb. of very strong alcohol, 1 lb. of bleaching powder—containing at least 20 per cent. bleaching chlorine—mixed into a paste with water, strained through linen, and the residue washed with water until the filtrate amounts to 1 lb. It is then mixed with a solution of carbonate of potash in 3 parts of water until no further precipitate is produced. The precipitate is separated by filtration, the warm alcoholic solution of shellac is treated with hydrochloric acid until the mixture is decidedly acid. The shellac then separates as white clots, which are to be washed until the water ceases to pass away milky, and then rolled out into thin strips upon a wet board.

(3) The shellac, previously broken into small pieces, is put into a flask, alcohol of 0·830 sp. gr. is poured upon it, and the whole is gently heated till the shellac is dissolved; next, so much coarsely powdered animal-charcoal is added to the solution that the whole forms thin paste; the flask is

closed almost air-tight, and exposed to gentle heat (e.g. the sun); in 8 to 14 days it should have a light yellowish-brown colour, and yield a clear pure polish on light woods. It is then filtered through coarse blotting-paper, for which purpose it is well to employ a tin funnel with double sides. The portion which first passes through the filter may be preserved separately, and used as a ground or first polish. Then some more spirit is poured over the charcoal upon the filter, and the solution used as a last coating. Shellac purified by animal charcoal has a brown-yellow colour, but is perfectly clear and transparent; when diluted with alcohol, the colour is so slight that perfectly white wood may be polished with it.

(4) Boil and dissolve the shellac in a solution of carbonate of potash (pearlash), then pass chlorine through the solution. This bleaches and precipitates the shellac. Wash the shellac with water, then boil it in water until it is soft; roll it into a ball, then pull it into ropes as pulling gives a satiny appearance. Boiling with weak solutions of pearlash alone will remove colouring matter, and it can then be pulled as described.

Silk.—A lye of white soap is made by boiling in water 30 lb. of soap for every 100 lb. of silk intended to be bleached, and in this the silk is steeped till the gum in the silk is dissolved and separated. The silk is then put into bags of coarse cloth and boiled in a similar lye for an hour. By these processes it loses 25 per cent. of its original weight. The silk is then thoroughly washed and steeped in a hot lye composed of 1½ lb. of soap, 90 gal. of water, with a small quantity of litmus and indigo diffused. After this, it is carried to the sulphuring room; 2 lb. of sulphur are sufficient for 100 lb. of silk. When these processes are not sufficiently successful, it is washed with clear *hard* water and sulphured again.

(*b*) Lyons process. The bleach is an *aqua regia*, prepared by mixing 5 parts of muriatic acid with 1 of nitric acid. Before being used, the mixture is left for at least 4 or 5 days at a gentle heat, about 77° F. (25° C.). When it is to be used it is to be diluted with about 15 times its measure of water, so as to stand at 3° to 4° Tw. This dilution is effected in large square tanks, cut out of grit-stone. The temperature of the liquid should be between 68° and 85° F. (20° to 29½° C.). The skeins being placed upon rods, they are plunged into the bath and worked without stopping, turning them quickly or drawing them from one end of the trough to the other. The process is generally complete in ¼ hour; but it is often at an end in 10 minutes and even less, according to circumstances. As soon as the bleaching is complete, the silk must be taken out, for a too prolonged stay in the acid would be very injurious. After being partially decolorised, it would next be dyed yellow and in a permanent manner. This treatment, therefore, demands great care. Silks of different kinds should never be treated together, as they do not bleach with the same speed. As soon as the desired effect is obtained, the silks are withdrawn and immersed successively in 2 troughs full of water, in order to remove every trace of acid without delay. They are then ready for stoving. Some prefer to work in the cold, as safer, though slower. Guinon, Marner, and Bonnet employ, instead of the *aqua regia*, a bath soured with nitro-sulphuric acid, i.e. sulphuric acid which has been allowed to absorb nitrous vapours (or a solution of chamber crystals). Chlorate of potash is also used with mineral acids.

(*c*) The method with peroxide of hydrogen is: The silk is first treated with soap baths, and then boiled with concentrated soap solution, in order to deprive it of its gum. It is then treated with carbonate of ammonia. The process for bleaching is the same as that for bleaching hair. After bleaching, a treatment in alcohol, to which some glycerine has been added, is recommended.

(*d*) Guinon proposes to bleach Tussore silk by steeping in soda-lye at 3° B., and at the heat of 212° F. (100° C.). It loses its gum and 12 per cent. of its weight, and is rendered white without loss of lustre. The treatment must not last longer than ½ hour. The silk is then washed and passed through dilute sulphuric acid. The fibre is not injured, but the affinity for colours is reduced.

(*e*) Palangié and Bedu are inventors of the following process for depriving raw Tussore silk of its natural colour, and rendering it capable of being dyed in all shades by ordinary methods: The silk after being deprived of its skin by the ordinary method, is entered into a bromine solution of a degree of concentration varying with the colour of the silk. In this bath it is left for ½ hour. The silk is then entered into a bath containing a dilute solution of an acid, and in this it is also left for ½ hour. Several bromine and acid baths may be necessary. Tartaric and citric acids give the best result. They can, however, be substituted by alkaline solutions, of which carbonate of soda is considered the best. Sulphides and acid sulphides and also sulphurous acid can be employed for the second bath.

(*f*) Lecouteur and Girard's method of bleaching Tussore silk. For 1 lb.: In a cold oxygenated bath (35 pints ammonia, ½ volume oxygen) the silk is left for 24 hours. The bath is then heated up to 122° F. (50° C.) and kept for 12 hours at this temperature. The same operation is repeated with a new bath, after which the silk is washed in a soap bath and rinsed with cold water. A bath containing binoxide of barium in suspension, through which carbonic acid is passed, after addition of a little bichromate of ammonia, gives the same results.

(*g*) The following is a summary of Moyret's remarks on silk bleaching:—

Silk Yarn. Scouring with weak caustic alkalies.—These, viz. caustic potash and soda (caustic ammonia has no action), are the most active, but, at the same time, the most dangerous, to employ, since with prolonged action, especially in the case of fine silks, the fibre itself is attacked. They are used, however, and with success too, for scouring the coarser and fancy kinds of silks. The hanks of silk are hung on sticks, and worked in a tub containing the scouring liquor, as in woollen yarn scouring. For 100 lb. silk, a solution of 3 to 4 lb. solid caustic alkali in about 300 gal. water heated to 140° F. (60° C.) is used, and the yarn is turned during ½ hour. It is then well washed and beaten. This plan is advantageous for coarse fancy silks, since it dissolves off the fine down of the fibres. For these qualities, the total loss in scouring is 10 to 12 per cent. of the weight of raw silk.

Scouring with Akaline Carbonates. This method, still used in China, has, notwithstanding its economy, almost entirely disappeared from European establishments on account of certain practical difficulties. The silk yarn is worked for 1 to 1½ hour, in a bath heated to 185° F. (85° C.) containing for 100 lb. silk, 10 to 12 lb. soda crystals. At first, the silk swells up and becomes gelatinous, then the outer envelope dissolves off, the fibre thereby becomes finer and more lustrous. It is sufficiently scoured when it produces a rustling noise on being rubbed with the nail, it is then washed 2 or 3 times with tepid water. The loss varies from 18 to 28 per cent.

Scouring with Soap.—This is pre-eminently the best method, since it preserves and even increases the valued properties of silk, such as feel, brilliancy, etc.; the soap used, however, should always be of the best quality. In the north of Europe, soft potash, soaps, generally made from linseed oil, are used; in the south, hard soda soaps made from olive and other oils are preferred. Of late years, soap made from oleic acid has been more and more employed. Those soaps are to be preferred which wash off best and leave, an agreeable odour. In general, those made from oleic acid and linseed oil wash off best; then follow the soaps made from olive oil, suet, etc. (containing stearic and margaric acids); last, and worst in this respect, comes palm-oil soap, which, on this account, has been almost entirely given up, notwithstanding its agreeable odour. For scouring silks which are to be subsequently dyed, oleic acid soap may be recommended; but for those destined to remain white, a good olive oil soap is best. In the latter case, two operations are necessary, "ungumming" (*dégommage*), and "boiling." For "ungumming," a boiling solution of 33 lb. soap to 100 lb. silk is used, the yarn being worked in this, from ½ to ¾ hour. Previous to placing the silk in this bath, however, it should be softened in a weak solution of soda crystals, or better still, of hydrochloric acid, and should be washed. For "boiling," the same bath may be used (if not too strongly charged with silk-glue), except for the purest whites, or when the raw silk is coloured; in these cases, a fresh bath is imperative. The yarn is lifted from the ungumming bath, and allowed to drain; the hanks are then wrung, sewn up in coarse hempen bags or "pockets," and boiled, during 2 to 3 hours, with a solution of 17 lb. soap per 100 lb. silk, The yarn is then rinsed in a weak, tepid solution of soda crystals, to avoid the precipitation of any fatty compounds on the silk, after which it is rinsed in cold water. For Japanese and Chinese silks, the loss may vary from 18 to 22 per cent.; for European silks, 25 to 27 per cent.

Scouring with Acids.—Moyret finds that an aqueous solution containing 5 per cent. of phosphoric or arsenic acid, has an action similar to that of the weak alkalies. Silk, previously moistened with dilute tepid hydrochloric acid to free it from lime, is ungummed, after boiling for 3 hours in the pockets with the above solutions. The process, however, has not been adopted, owing to the fact that the silk is not rendered so white, and is not so capable of being properly weighted afterwards.

Silk Yarn Bleaching and Tinting.—After scouring, the yarn is opened out, to be hung on sticks, and worked in a bath containing 10 lb. soap per 100 lb. silk, at a temperature of 120° to 140° F. (49° to 60° C.); it is then drained and straightened out, ready for being sulphured. The total amount of good olive-oil soap required to scour silk for white, varies from 50 to 60 per cent. of the weight of the latter in the raw state.

Sulphuring.—For this purpose, the hanks while still damp and well straightened out, are hung in the sulphur chamber (which is of the same construction as that for woollen bleaching), and are there exposed to the fumes of burning sulphur for 5 to 6 hours, or even over night. Afterwards, the silk is well rinsed in a weak tepid solution of soda crystals, in order to wash out the sulphurous and sulphuric acids absorbed by the fibre. To ensure the thorough expulsion of the former, it is customary to hang the rinsed hanks, after wringing out the water, in a stove heated to 85° to 100° F. (29° to 38° C.). With reference to the bleaching of silk by sulphurous acid, Moyret's opinion seems to be that probably it does not act directly in destroying the colouring matter of the fibre; but that along with the formation of sulphuric acid there is also a production of ozone.

Tinting.—This operation is necessary to hide the faint yellow hue which the silk still retains. Unlike the analogous operation in use with cotton and wool, the question here is not always one of simple blueing; to suit the tastes of the merchants, the silk is actually dyed in various delicate shades, e. g. milk-white, snow-white (pure-white), azure-white, bluish-white), Chinese-white (orange, yellowish and purplish whites). To obtain pure white, a very weak neutral bath of ammoniacal cochineal and indigo carmine is used, care being taken that the dye should not too rapidly fix itself on the fibre; to prevent this a little ground chalk is added to the bath. A cold or slightly tepid solution of aniline violet, with addition of a little soap, is also very much used for this shade. To obtain Chinese white, a weak soapy solution of annatto may be employed. After tinting, the silk is rinsed in fresh water and dried in a moderately warm stove, admitting as little light as possible.

Scouring and Bleaching Woven Silk. Before scouring, the goods are singed with the gas flame (as in cotton bleaching). The scouring machine consists simply of a winch set over a wooden box or tub. As with the silk yarn, so here, there are two operations, "ungumming" and "boiling," both of which can be done with the same machine. For ungumming, the piece is simply winched backwards and forwards, for about an hour, in an old boiling liquor at 212° F. (100° C.). After winding the piece on to the winch and allowing it to drip, the liquor is run off and the tub is refilled with fresh liquor, containing 30 to 40 per cent. of white soap, and heated to incipient boiling. The piece is then unwound and again winched backwards and forwards for about 2 hours; it is then rewound on to the winch, and allowed to drip for ½ hour, when it is ready to be rinsed for dyeing in dark shades, or to be bleached for pale or white shades. Sometimes, in order to save time, the boiling is done in pockets as in the case of silk yarn. For rinsing, the winch with the silk wound on it is transferred to another tub containing a weak solution of soda crystals, where it is unwound and winched for ¼ hour, after which it is removed to be streamed in running water, and beaten, till thoroughly clean and ready for dyeing. If for sulphuring, a fresh weak soap bath heated to 120° F. (49° C.) is given, instead of rinsing; and, after draining, the pieces are hung in the sulphur stove. According to the degree of purity of white required, this soaping and sulphuring is repeated several times.

Silver Dials.—Clean the dial by any ordinary means, then black it over the flare of gas, continue heat till black burns off, then pickle in vitriol and water, 1 in 20.

Sponge.—(1) Saturate in a quart of buttermilk for 24 hours, and rub between the hands. (2) soak in dilute muriatic acid (1 acid to 1½ water) for 12 hours, wash well with water, to remove lime, then immerse it in a solution of 2 lb. hyposulphite of soda in 12 lb. water, to which 2 lb. muriatic acid has been added a moment before. After it is sufficiently bleached, remove, wash again, and dry. (3) Soak for several days in cold water, renewing the water and squeezing the sponges occasionally. Then wash in warm water, and put into cold water acidulated with hydrochloric acid. Next dry, take out, and wash thoroughly in soft water; then immerse in an aqueous sulphurous acid (sp. gr. 1·034) for a week. Afterwards wash in plenty of water, squeeze, and allow to dry in the air. (4) Soak in dilute hydrochloric acid to remove the lime, then wash in water and place for 10 minutes in a 2 per cent. solution of potassium permanganate. Their brown appearance on removal from this is due to deposition of manganous oxide, which may be removed by steeping for about 2 minutes in a 3 per cent. solution of oxalic acid, to which a little sulphuric acid has been added. As soon as the sponges appear white, they are washed out in water to remove the acid. Very dilute sulphuric acid may replace the oxalic acid. (5) First wash in tepid water, and then in a solution of hydrochloric acid (5 c.c. per *litre* = 5 fl. dr. per 7 pints), which frees the pores from carbonate of lime; next immerse for 24 hours in a solution composed of 5 pints hydrochloric acid in 100 of water, with addition of 6 pints hyposulphite of soda. (Blondeau.)

(6) Wash first in weak muriatic acid, then in cold water; soak in weak sulphuric acid, wash in water again, and finally rinse in rose-water.

Starch.—Potato starch is largely bleached by the application of sulphuric acid, this being absolutely requisite when the potatoes are at all decayed. After the use of the sulphuric acid any remaining traces of acid must be neutralised by ammonia or milk of lime, fixed caustic alkalies being inadmissible. Chlorine is also much used for bleaching starch, usually as a solution of calcium chloride in water soured by the addition of sulphuric acid ; this and some other salts cause the grains to swell, and render them soluble in cold water. Sal-ammoniac is another favourite agent.

Straw.—On a small scale, with such an article as a straw hat, a bonnet, a basket, etc., the following method may be followed: (1) The straw, having been well washed with weak soda lye, is rinsed in plenty of clean water lightly shaken, etc. ; remove superfluous moisture, and place, supported on a stick, under a large glazed earthenware pan (turned upside down). A very small pipkin, capable of holding about ½ pint is now placed on the fire, and about ½ oz. of roll brimstone placed in it. When the brimstone is all melted, a light is applied to it, so as to cause it to catch fire. The pipkin with the inflamed sulphur, is now placed under the glazed pan in such a position as not to scorch the article to be bleached. The spaces between the pan and the table or floor on which it rests, must be carefully closed with damp cloths placed around to prevent the escape of the sulphurous acid gas produced by the combustion of the sulphur. In about 2 hours the pan may be removed, when the straw will be found nicely bleached. N.B.—This operation had better be performed out of doors, as the sulphurous acid gas which is set free on lifting the pan, is extremely irritating to the chest and throat. (2) Or the articles, having been washed as before, may be placed for an hour in weak chloride of lime water, and then hung out on a line to dry slowly. The chloride of lime water should be made by mixing 1 part (by weight) of chloride of lime with 20 of water, agitating the mixture with a stick, until all the particles of chloride of lime are thoroughly broken up allowing the mixture to settle, and pouring off the clear portion from the dregs for use. (3) In Tuscany, where a considerable amount of straw is bleached, the straw is selected while the wheat is bearded, and the grains still in a soft milky state. In order to ensure the requisite fineness, the corn is sown very thickly, so that the straws are in a dwindled condition. The straws are cut, spread out for 2 or 3 days to dry out the sap, tied up in bundles, and stacked to allow all moisture to dry off. They are then again spread out exposed to the dew and atmosphere, turned over several times, and watered with clean water. After this, the lower joints are cut off, the chosen portions exposed to the action of steam in a steam vat, which further decolorises them, and lastly bleached by exposing to sulphurous acid vapours in closed chambers. (4) In this country, the straw is prepared by acting upon ordinary materials; first, with a solution of caustic soda, boiling, by which a considerable portion of the organic matter and natural varnish is disintegrated; after this it is washed well to remove all the material which the alkali dissolves, and then exposed to the action of sulphurous acid or chlorine in closed vessels. (5) Kurrer states that straw may be economically whitened by being steeped repeatedly in boiling water and very weak alkali, and, after all the soluble matters are in this way removed, by treating alternately with very dilute solutions of chloride of lime and sulphurous acid vapour, until decoloration has been effected. This method, though tedious, is said to be very effectual for divesting the straw of its natural varnish, which renders it very brittle. (6) About 9 oz. of permanganate of potash are dissolved in 1 gal. of warm water. This is done in an earthenware vessel, and cold water is then added until the liquid takes a dark red colour. The straw is left for about 6 hours in a tepid and weak solution of soda crystals. It is then washed carefully and introduced into the permanganate solution, in which it is continually agitated. As soon as it has taken a light brown colour, it is dipped in cold water, then in a bath of bisulphite of soda, strong enough to be smelled. In this bath the straw is left for 15 minutes, and when taken out it is perfectly white. (7) Soak the goods in caustic soda, and afterwards use chloride of lime, or Javelle water (chloride of potash). The excess of chlorine is afterwards removed by hyposulphite of soda (antichlor).

Wax.—(1) Melt the wax in a jar, and put into it powdered nitrate of soda (Chili saltpetre) in the proportion of 1 oz. to the lb. of wax; afterwards add, by degrees, 2 oz. to the lb. of sulphuric acid, diluted with 10 times its weight of water, keeping the wax warm and stirring the while. Let it stand a short time, and then fill up the jar with hot water, and allow the whole to cool. The wax should then be white. Afterwards wash with water to remove any nitric acid that may remain, as it would make the wax yellow.

(2) Melt the wax with about 3 per cent. of water in a bright copper vessel, preferably heated by steam, and when the whole is liquid, and has boiled for a few minutes, withdraw the heat. Then sprinkle over it some oil of vitriol in the proportion of 3 oz. or 4 oz. (fluid) to every cwt. of wax. Be careful in doing this, as if done carelessly the melted wax will froth up and boil over. The oil of vitriol should be scattered over the whole surface. Cover it over, and allow it to settle. Then skim it gently with a hot ladle and bale it into vessels to cool. Take care not to disturb the sediment. To bleach the wax, expose it in thin flakes to the action of the sun, wind, and rain. Sometimes it is advisable to change the surface exposed by remelting it, and again making it into thin flakes.

(3) Wax for candle-making is bleached by being melted in hot water or by steam in a wooden or tinned-copper vessel. It is allowed to settle, and the waxy superstratum is run off while fluid into a wooden trough, having a row of perforations in the bottom, by which it is distributed upon horizontal wooden cylinders revolving with their lower portions surrounded by cold water. The ribbons or fibres made in this way are exposed to the bleaching action of the atmosphere and sunlight, being frequently moistened and turned over during the process. It is necessary to guard against wind, which might scatter the shreds; hence large cloth covers are kept in readiness. The operation is continued till the wax becomes perfectly white. It is usually conducted in Britain between April and September, the weather not being propitious at other seasons. In France, it is customary to add a little cream of tartar or alum to the water in which the wax is melted, whereby the bleaching is much curtailed. Bleaching agents like chlorine render wax unfit for candle-making.

(4) Paraffin wax is treated by mixing with a little strong sulphuric acid and heating to 150° C. This has the effect of charring the colouring matter, but does not injure the paraffin. After being allowed to cool, water is added and the whole boiled. When cool the wax forms a cake on the surface, which is then rinsed and dried. Filtering through animal charcoal, in a steam jacketed pan, produces an excellent colourless product.

Wicker-work.—Make a solution of 1 part chloride of lime with 20 parts water. Well mix, then let stand, and run off the clear liquid into a wooden tub. Dip the baskets in this and let them stay half an hour. Remove them from this solution, then dip in hydrochloric acid and water (1 to 20); let remain quarter of an hour, then wash in plenty of water, and let dry in a cool shady place.

Wool.—The wool is first prepared

according to the purposes for which it is intended, by treating it with solutions of soap. By this process it is cleared of a great quantity of loose impurity and grease which is always found in wool, often losing no less than 70 per cent. of its weight. The heat of the lye must be carefully attended to, as a high temperature is found to fix the unctuous matter or yolk of the wool. After washing it is taken to a sulphur chamber, where it is exposed to the fumes arising from the slow combustion of sulphur, for from five to twenty hours, according to circumstances. It is again washed, and then immersed in a bath composed of pure whiting and blue. It is then exposed a second time to the fumes of the sulphur, and washed with a solution of soap, which renders it of the proper whiteness. (*See also* articles on Bleaching in Spons' 'Encyclopædia.')

* * *

BOILER CORROSION.

(*a*) Extensive internal corrosion frequently occurs in boilers using water that has been passed through surface condensers over and over again. To prevent the corrosion add sufficient soda to the feed-water to make the water in the boiler alkaline, and place rolled zinc plates in good metallic and electrical connection with the inside of the boiler and under water, so that no part of the boiler is more than 6 ft. from the zinc, and renew the zinc when it is wasted.

To prevent corrosion in idle boilers fill them with water in which about 50 lb. of common soda has been dissolved to each 100 cub. ft. of water. If the water is sufficiently alkaline after this is done, a bright nail hung in the water will not rust.

The French Navy uses this system: The boilers are first completely filled with sufficient water, and a solution of milk-of-lime or soda is added to the water. The solution is made stronger if the tubes are large, and of less strength if they are small, in order to avoid the danger of contracting the effective area by deposit from the solution.

The outside of the steel or iron tubes is painted with red lead or tar as far as the parts are accessible. For those parts which are inaccessible a protective coating is obtained by burning tar under them.

In the American Navy, boilers not in use are thoroughly cleaned and painted with a mineral oil.

In the English Navy, after cleaning, boilers are thoroughly dried and a pan of charcoal burned in them to consume the oxygen of the air, and quicklime is used to absorb any moisture that may remain.

To prevent rust in unused boilers, it is advisable to keep them filled with water, and the exterior well painted. (W. W. Christie.)

(*b*) External corrosion of boilers chiefly arises from damp in any brickwork in which they may be set, therefore it should be kept as dry as possible, and should be coated with a waterproof composition. Moisture may be communicated to the brickwork, in addition to the usual means, by leakage through rivet-holes, longitudinal seams, and other defects, or want of sufficient care in preventing water or damp air reaching it, particularly if a boiler be wholly or partly below ground level. Great width of bearing surface of a boiler on brickwork is liable to increase, if it be not the cause of, corrosion, for water will trickle towards it, and there remain.

Boilers placed on a broad wall perpendicular to their vertical centre are specially liable to corrode, as then the lowest portion of their whole circumference is seated on brickwork. Consistent with sufficient bearing, the bedded surfaces should be as small as possible, in order that but little of the entire circumference of the shell be covered. Material of a hygroscopic nature should not be used to join a boiler to the brickwork setting, and therefore fire-clay is considered far preferable to lime mortar. The longitudinal seams should be so arranged that they can be inspected and caulked, and therefore should not be covered. The joints and any flaws in the boiler-plates and vulnerable places, and suffer most from heat and other causes.

(J. Newman.)

BOILER INCRUSTATION

AND

BOILER COMPOSITIONS.

THE extent and character of the solid matters in the various natural waters at the disposal of the boiler-owner (the so-called natural mineral waters, such as those of Bath, Buxton, and Harrogate, are here left out of account) vary considerably, and depend upon the nature of the ground. Thus in limestone districts, as in Derbyshire, or in chalk districts, such as in the London district, there is much carbonate of lime in the water; in slate and granite districts, as in Cumberland and Cornwall, the waters are fairly pure, and contain very little matter in solution; in Yorkshire, where there is a good deal of magnesium limestone, the waters contain much magnesia in solution; river and brook waters which flow over the surface are more charged with vegetable organic matter than are well and spring waters. The chief impurities usually present are the carbonates of lime and magnesia, and the sulphates of the same two earths; common salt (sodium chloride) is present in all waters; silica is a common constituent; some waters contain magnesium chloride.

The analyses of various boiler waters that have come under the writer's notice are given in the table below. The figures are expressed in grains per gallon.

These figures serve to demonstrate how wide is the variation in the waters that owners of boilers in various districts have to deal with. The analyses of scales from various waters, page 147, also show this great variation.

In A, B, and C, it is the carbonates of lime and magnesia which form the great bulk of these scales, while in D, E, and F, it is the sulphate of lime.

Source of Water.	Well.	River.	Town Supply.	Canal.	Well.	River.	River Mouth.
Sodium Chloride . . .	1·65	0·82	4·32	5·28	5·28	3·05	52·68
Lime Carbonate . . .	10·00	0·98	13·18	10·99	1·39	16·39	10·46
Lime Sulphate . . .	..	0·22	1·03	2·99	54·15	4·30	5·32
Magnesium Carbonate .	4·76	0·14	1·24	2·76	1·78	0·31	2·68
Magnesium Sulphate. .	..	..	2·34	12·41	22·46	1·28	4·28
Sodium Sulphate. . .	4·15	..	..	18·96	28·96	..	1·34
Oxide of Iron	..	..	..	0·13	..	..	..
Organic Matter . . .	2·22	0·68	3·20	6·24	2·45	5·68	10·56
Silica	..	..	0·50	0·31	0·36	0·42	0·13
Total Solids	22·78	2·84	25·81	70·03	116·83	31·43	87·45

There is some difference in these two classes of scales; those which contain the carbonates chiefly are usually brittle and pulverulent, while if there is but little sulphate, as in A and C, then the scale may be powdery rather than adherent. On the other hand, owing to the more crystalline nature of lime sulphate, the scales, in which it occurs principally, are hard and crys-

—	A.	B.	C.	D.	E.	F.
Lime Carbonate	32·16	50·04	75·92	1·22	17·31	11·21
Lime Sulphate	5·64	29·76	3·16	78·32	33 76	60·36
Magnesium Carbonate	20·04	10·84	10·16	10·36	18·04	15·36
Alkaline Salts	3·31	0·86	0·84	0·64	0·54	0·21
Silica and Insoluble	17·70	0·48	0·22	0·56	0·33	0·68
Organic Matter	6·91	4·44	6·21	3·54	6·36	6·24
Oxides of Iron and Alumina	7·46	2·36	2·96	4·64	2·88	4·06
Water	6·78	1·22	1·53	0·72	0·78	1·88

talline, difficult to break up and remove.

The chief scale formers which boiler owners have most to dread are the carbonates and sulphates of the two earth metals, lime and magnesia, particularly the sulphates, because these form the hardest scale. Alkaline salts are not of much moment, while silica and other substances are usually present in too small an amount to exert any material effect. The question arises, Can the formation of scale be prevented in any way?

There are two ways in which this is done at the present time. The best plan is to adopt some method of softening the water—that is, removing the lime and magnesia compounds before the water goes into the boiler. This is the better plan but it necessitates a special plant, to the cost of erection of which, and the labour involved in attending to it, many boiler owners object.

The next method is to add to the water in the boiler some substance which shall so react with the constituents of the water as to change their properties, converting them from scale formers into sludge by periodical opening of the blow-off taps. Many boiler users do not give as much consideration as they might do to the quantity of solid matter they put into their boilers, and what becomes of it.

Alkalies.—When the water contains carbonate of lime and magnesia chiefly, very little of anything is needed, as these are deposited in a loose form by the mere boiling of the water, for they owe their presence in the water to the fact that they are only soluble in water containing carbonic acid gas in solution; and on boiling, this gas passes away, and consequently the carbonates are deposited. The addition of some caustic soda will assist in this action.

In the case of sulphate of lime, it is desirable to add some carbonate of soda to decompose it, and convert the sulphate into carbonate of lime, sulphate of soda being formed at the same time. In the case of magnesia sulphate, caustic soda acts better than carbonate of soda, oxide of magnesia, which is more insoluble and bulky than carbonate of magnesia, being thrown down. Hence it will be found that carbonate of soda in its various forms of soda crystals, soda ash, or ammonia alkali and caustic soda, form the basis of most boiler compositions.

Alkaline Salts.—Of the saline bodies, borax and phosphate of soda have often been used, and may with some waters prove useful, but they are costly; they will act by throwing down the lime and magnesia as the borates or phosphates of those earths, and these are very insoluble and amorphous in their nature. Oxalate of soda has been used in some cases with beneficial results when the water contains much lime, oxalate of lime being formed, which is also very insoluble.

Permanganate of potash has also been used, but how it acts is uncertain, except as destroying the organic matter.

Oils and Fatty Matters.—Fatty matters were much used at one time, but now seem to have been given up. Certainly, they cannot be considered as satisfactory additions to a boiler. Under the conditions present they must undergo decomposition into fatty acid, and this will act corrosively on the boiler plates and fittings. Paraffin and petroleum oils are also objectionable.

Tannin and Vegetable Bodies.—Various tannin matters, such as chestnut extract, sumac extract, gambier and sumac, are often added to boiler compositions, partly as colouring matters, partly on account of their influence on the formation of scale. While they can hardly have much, if any, chemical effect, yet their presence will exert a mechanical influence in keeping the scale open and loose, easily to be drawn off through the blow-off cock.

As they are generally presented in a dry form, they should be well soaked in water before being introduced into the boiler, else they are liable to be carried over mechanically with the steam, and give much annoyance by choking the pipes and valves. Care must be taken also where the steam is to be blown into tanks for heating purposes, as in flax and hemp boiling, the tannic acid forming with the iron present in the fibre a black stain or blot, which cannot be bleached without the use of an acid, and consequent liability to damage the tissue.

Starch is often added partly to give a false idea of the strength of the composition, partly to act in the same way as the tannin matters.

Summarising the matter of these compositions briefly, one may say that where the carbonates of lime and magnesia only are concerned, then caustic soda is the best agent to use; where the sulphate of lime predominates, then carbonate of soda, with a small amount of oxalate of soda, or phosphate of soda, may be employed. When magnesia salts are abundant, then caustic soda should predominate in the composition.

There is one point that should not be overlooked; some waters contain much organic matter—often this has an acid character, and tends to corrode the boilers. This is partly corrected by the alkalis added, but it is as well to destroy it, and here it is that permanganate becomes useful.

The following may be taken as typical boiler compositions:—

(*a*) Powder—

1. For limey waters:
    1 cwt. ammonia alkali, 58 per cent.
    10 lb. 98 per cent. caustic soda.
    2 lb. oxalic acid.
2. For limey waters with much organic matter:
    1 cwt. ammonia alkali, 58 per cent
    10 lb. 98 per cent. caustic soda.
    2 lb. permanganate of potash.
3. For magnesium waters:
    1 cwt. ammonia alkali, 58 per cent.
    28 lb. 98 per cent. caustic soda.
    5 lb. phosphate of soda.
4. For magnesium waters with much organic matter:
    1 cwt. ammonia alkali.
    28 lb. 98 per cent. caustic soda.
    5 lb. phosphate of soda.
    2 lb. permanganate of potash.

(*b*) Liquid—

To the materials given below add water to make up to any desired strength (usually the quantities given will do to fill a 40-gal. cask).

1. For limey waters:
    84 lb. ammonia alkali.
    10 lb. caustic soda.
    2 lb. oxalic acid.
    3 lb. cutch.
2. For limey waters:
    84 lb. ammonia alkali.
    10 lb. caustic soda.
    2 lb. oxalic acid.
    3 lb. cutch.
    3 lb. farina.

3. For magnesium waters:
   - 76 lb. ammonia alkali.
   - 20 lb. caustic soda.
   - 2 lb. phosphate of soda.
   - 3 lb. cutch.
4. For waters with organic matter:
   - 76 lb. ammonia alkali.
   - 20 lb. caustic soda.
   - 3 lb. phosphate of soda.
   - 2 lb. permanganate of potash.
5. For waters with much sulphates:
   - 84 lb. ammonia alkali.
   - 20 lb. caustic soda.
   - 3 lb. oxalic acid.
   - 5 lb. cutch.

These will show how to build up a composition.

As to the quantity to be added, it is a safe plan to add 10 gr. of ammonia alkali or caustic soda to every 10 gr. of lime and magnesia compounds in the water.

('Decorators' Gazette and Plumbers' Review.').

Other Organic Compositions.—Peat or moss has been used in many cases with the best results, whilst with some waters potatoes act well. The residue in the boiler is soft, and the blowcock should be frequently used. Many other organic materials have from time to time been in the market. They form an important class of substances, and many of them give good results. The analyses of the incrustations show an increase in the proportion of organic matter, but otherwise they do not materially differ from those obtained from the same waters when no anti-incrustator is used.

These organic substances are frequently mixed with salts, and have then the properties of both classes—that is to say, chemical and mechanical actions. They are liable, however, when used with hard waters, to form somewhat dense cakes, which become more or less hard, are charred, and cause overheating and consequent damage. This seems to be due to an excess of the saline constituent, for natural substances containing little alkaline base in proportion to organic constituent do not seem to give similar results. The saline ingredient is generally caustic soda or soda ash.

No attempt should be made to soften water or employ anti-incrustators without first making a searching inquiry as to the nature of the waters available and the scale they may form. No special law can be laid down for the softening of water or the use of anti-incrustators—the cause of the disease must first be learned, and then the remedy may be safe and sure. To limit the materials used, by laying down a hard and fast rule, would be to cause injury and loss to the steam user. The best results are obtained by the employment of a man of skill, and the rigid working out of his suggestions.

A writer in 'Le Technologiste' discusses the processes employed to prevent boiler incrustations under 3 classes: (1) chemical; (2) chemical and mechanical combined; (3) physical.

Chemical Processes.—These consist in the use of certain solvent substances introduced into the boiler to precipitate salts contained in the water. The non-adherent, muddy deposits thus formed from the calcareous matter are from time to time removed, that they may not by their presence be an obstacle to the action of heat. Colouring matters, dyewoods, and in general all woods containing tannin, can be used for the purpose, when the waters contain neither sulphates nor chlorides. Various other products having for base fecula, lime, and baryta, are also employed with success; but the constitution of the substances used should be suited to the nature of the water. The chief inconvenience in using these products is that most of them corrode the boiler-plates, and produce a froth in the water with which they are mixed, containing precipitated fragments, which, in consequence of their small size, are readily carried by the steam into the valves and cylinders of the engine, where they may injure the joints through friction, and cause an escape of the steam.

Chemico-Mechanical Processes.—In the processes just referred to, it is of course necessary to open the boiler in order to remove the deposits, and this may sometimes require a stoppage of work for an entire day. This disadvantage would be obviated if, instead of putting the anti-calcareous matters into the boilers, they were put in the feed water, and this water filtered (after heating) before being introduced into the boiler. Apparatus of this kind is now very largely used, the precipitating matters being mixed, by mechanical agitation, with the feed water in large reservoirs. When the mixture is sufficiently complete, the muddy water is decanted during 10 or 12 hours, and filtered previous to use.

Physical Processes.—By heating the water to a high temperature, it is possible to purify it from all the sedimentary matters contained in it. These matters are decomposed and precipitated, and cannot adhere to the walls of the vessel containing them till the temperature of the water is lowered. The temperatures at which the calcareous matters are precipitated are the following:—

Carbonates of lime, between 176° and 248° F. (80° to 120° C.).

Sulphates of lime, between 284° and 302° F. (140° to 150° C.).

Chlorides of magnesium, between 212° and 257° F. (100° to 125° C.).

Chlorides of sodium, between 302° and 320° F. (150° to 160° C.).

When the water contains only carbonates of lime, it suffices to heat to a temperature of about 212°F. (100° C.), which may easily be obtained from the exhaust steam of the engine, and with ordinary air-pressure. When the water contains sulphates of lime or chlorides of sodium or of magnesium, as sea-water, it must be raised to a higher temperature, which has to be obtained by heating under pressure. In this case, the steam must be taken from the boiler—a fact which proves obstructive to the general use of such apparatus.

Use of Zinc.—This consists in introducing into the boiler some small ingots or clippings of zinc; it is then observed that the usual earthy substances, instead of forming a hard and adherent deposit, form a non-coherent crust, which can be readily removed. If the water be very strongly impregnated with lime salts, the deposit, even if coherent and solid, does not adhere firmly to the boiler plate. The zinc is converted into a white earthy mass, principally oxide of zinc. No trace of zinc can be detected in the water, and there is very little in the ordinary incrustation, as the oxide of zinc forms a separate deposit. Experience has shown that about 2 lb. of zinc per month per horse-power is sufficient. The action of the zinc, being in contact with the iron boiler plate, is probably electrical, and, if hydrogen be evolved in small bubbles, it would be sufficient to account for the deposit being non-adherent and friable.

A boiler with clean plates yielded with 1 lb. coal 7·5 lb. steam, after two months only 6·4 lb. steam, or a decrease of 17 per cent. At the same time the boiler had suffered by continual working. Suppose a boiler free from inside crust would yield a saving of only 5 per cent. in fuel (and this figure is taken very low compared with practical experiments), it would be at the same time a saving of 1½*d.* per cub. yd. of water. If the cleaning of 1 cub. yd. of water therefore costs less than 1½*d.*, this alone would be an advantage. For a long time, efforts have been made to find some means for this purpose, and we have reached good results with lime and chloride of barium as well as with magnesia preparations. But these preparations have many disadvantages. Corrosion of the boiler iron and muriatic acid gas have been detected. Chloride of calcium, which is formed by using chloride of barium, increases the boiling-point considerably, and diminishes the elasticity of steam; while the sulphate of soda, resulting from the use of carbonate of soda, is completely ineffectual against the boiler iron. It increases the boiling-point of water less than all other salts, and diminishes likewise the elasticity of steam. (Wullner.)

Magnesia.—In using magnesia preparations the precipitation is only very slowly and incompletely effected—one part of the magnesia will be covered by the slush and the formed carbonate of magnesia in such a way, that it can no more dissolve in water and have any effect ('Dingler's Polyt. Journ.'). The use of carbonate of soda is also cheaper than all other above-mentioned substances. One *milligramme* equivalent sulphate of lime in 1 *litre* = 68 *grm.* sulphate of lime in 1 *cub. m.* requiring for decomposition: 120 gr. (68–88 per cent.) chloride of barium of commerce—cost, 0·6*d.*

Or 50 gr. magnesia preparation—cost, ½*d.*

Or 55 gr. (96–98 per cent.) carbonate of soda—cost, 0·41*d.* The proportions of cost by using chloride of barium, magnesia preparation, carbonate of soda will be 6 : 5 : 4.

Carbonic Acid.—Method adopted by Schübler. It is liquid carbonic acid, which he brings in a cylinder in connection with the boiler, which, though cold, is still filled with water. The water hereby becomes saturated with carbonic acid. This carbonated water then dissolves the carbonate of lime, the principal part of the incrustation, and forms an acetous carbonate of lime, which falls off, and, after removal of the water, the boiler will be found free from the incrustation.

Delfosse's Patent.—If the boiler be stationary, and fed with fresh water, the amount of anti-petrifying mixture per horse-power for 336 hours' consumption may be made by mixing together 2 oz. muriate of soda, 2 dr. of dry tannic or gallic acid, 2½ oz. of hydrate of soda, or 1 or ½ oz. of subcarbonate of potash. For locomotive boilers travelling an average of 140 miles per day, the quantity of the mixture per horse power is increased one-fifth. If the water be brackish, or a mixture of salt and fresh, the muriate of soda is omitted, and instead 12 oz. are used for 2½ oz. of hydrate of soda, and 5 dr. instead of 2 of the dry tannic or gallic extract. The mixture is also prepared in this manner when sea water is used in the boiler. The patentee prefers introducing the mixture into stationary boilers in quantities for two, three, or more days, but locomotive and marine boilers are to be supplied daily with a portion of the mixture, corresponding with the amount of duty to be performed.

The 'Chemical Engineer' gives an account containing a number of compounds that have great efficacy in preventing boiler incrustation.

Glycerine.—M. E. Asselin, of Paris, recommends the use of glycerine as a preventative. It increases the solubility of combinations of lime, and especially of the sulphate. It forms with these combinations soluble compounds. When the quantity of lime becomes so great that it can no longer be dissolved, nor form soluble combinations, it is deposited in a gelatinous substance, which never adheres to the surface of the iron plates. The gelatinous substances thus formed are not carried with the steam into the cylinder of the engine. M. Asselin advises the employment of 1 lb. of glycerine for every 300 lb. or 400 lb. of coal burnt. To prevent boiler incrustation:—

1. For a 5 H.P. boiler, fed with water which contains calcic sulphate, take: Catechu, 2 lb.; dextrine, 1 lb.; crystallised soda, 2 lb.; potash, ½ lb.; cane sugar, ½ lb.; alum, ½ lb.; gum arabic, ½ lb.

2. For a boiler of the same size, fed with water which contains lime: Turmeric, 2 lb.; dextrine, 1 lb.; sodium bicarbonate, 2 lb.; potash, ½ lb.; alum, ½ lb.; molasses, ½ lb.

3. For a boiler of the same size, fed with water which contains iron: Gamboge, 2 lb.; soda, 2 lb.; dextrine, 1 lb.; potash, ½ lb.; sugar, ½ lb.; alum, ½ lb.; gum arabic, ½ lb.

4. For a boiler of the same size, fed with sea water: Catechu, 2 lb.;

Glauber's salt, 2 lb.; dextrine, 2 lb.; alum, ½ lb.; gum arabic, ½ lb.

When these preparations are used add 1 qt. of water, and in ordinary cases charge the boiler every month; but if the incrustation is very bad, charge every 2 weeks.

Filtering the feed is an excellent precaution, and should be universally adopted; but to prevent the corrosive action in marine and other boilers of substances which no filtering can arrest, Rowan thinks nothing better can be suggested than forming on the interior surfaces an artificial coating of calcium sulphate and magnesium hydrate, in proportions varying with the pressure carried in the boiler. The mixture can be easily fed in in the form of a thin whitewash with fresh water; but to obtain the best results it should be supplied at the commencement of the boiler's career, before corrosion has unfitted the surfaces of the plates for the adherence of the protective coat. It is claimed that when once hardened by heat, the artificial scale thus made with fresh water cannot be dissolved by fresh water, and is not likely to be affected by the small quantity of sea water which may leak in; that its thickness is quite under control; and that it is safe and free from the trouble attending the keeping up of a salt scale.

* * *

BOILER AND PIPE COVERING COMPOSITIONS, TO PREVENT LOSS OF HEAT.

(*See also* SILICATE COTTON OR SLAG-WOOL.)

(*a*) Take a bushel of fire-clay, a bushel of common clay, a bushel of cow dung, 3 pints of tar, a peck of fine ashes, and a small quantity of plasterer's hair. Moisten with water and mix to the consistency of mortar. The following is the method of application.* First heat the boiler or pipe surface to about 120° F., then with the hand or a cloth, or a suitable brush, rub a thin coat of the mixture on to the boiler. The object of this is to get the material to adhere. When this is done (and left rough, not smoothed), the first coat can be put on. This is applied with a trowel and should not be more than ½ in. to ¾ in. thick. Let it be very roughly finished, to make a key for the next coat, and let it stand one day to dry. Moisten the dried surface with water or some of the mixture diluted to a wash and apply the second coat, leaving this rough, as the last, and allowing it a day to dry. Repeat the process for the last coat, but this can be trowelled smooth. The three coats should make at least 2 in. thick, while in certain cases four coats and a total thickness of 3 in. are needed. In certain cases, plaster is mixed with the last coat so as to admit of a good finish with the trowel. If there is any likelihood of the covering being knocked or roughly used, it can have a final covering of damp canvas put on while the last coat of composition is soft. When dry the canvas is painted. In some cases fine wire netting is put over the covering, With pipes of moderate size, the canvas covering, if used, is cut into strips. 6 in. wide, and wound on spirally.

(*b*) Take 6 parts sifted coal ashes, 4 parts fire-clay, 1 part common clay, 2 parts plaster of Paris, 1 part of flour, 2 parts cow dung, clear of straw, 2 parts cow-hair, ½ part of coal tar, and mix altogether to the consistency of mortar, using what water is necessary for this. Apply exactly the same as with the preceding recipe (*a*).

(*c*) 5 cwt. of fossil meal,† 5 cwt. fine road dust, 5 cwt. cow dung, 1 cwt. fire-clay in powder, about a bushel of finely cut chaff, 4 lb. well separated cow-hair. This, when well mixed, can be stored dry and when required for use moistened with water to the consistency of mortar. A rather special feature with this, as with all similar mixtures is that well working it in the moist state tends to toughen and improve it. Apply this mixture as described with the first recipe (*a*).

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* The method here described has to be followed with nearly all compositions of the kind.

† Also known as "Kieselguhr."

(*d*) A mass highly recommended is prepared as follows: 100 parts by weight of finely ground limestone, 350 of finely ground coal, 250 of pulverised clay, 300 of fine ashes from boiler-flues are thoroughly mixed with 600 of water and 10 of sulphuric acid of 50° Bé., and after adding 15 of hair (cow-hair or calf-hair) the whole is made as homogeneous as possible. The article to be covered should, if possible, be previously heated. The mass is then gradually applied in separate layers, each about ¾ in. thick, until a thickness of 2 to 2¾ in. is attained. The whole may finally be painted any colour desired.

(*e*) Boil 1 lb. each of rice flour, rye flour, cows' hair and treacle with 150 qt. of water, and gradually and with constant stirring add 80 lb. of infusorial earth or fossil-meal. Apply the mass in several layers to the lukewarm pipes.

(*f*) Waste of cork, asbestos, gypsum and cement, all finely ground, are, shortly before use, made with water into a paste of the consistency of mortar. The resulting mass is applied with a trowel to the objects to be insulated. It answers the purpose far better than masses containing hair, glue, treacle, etc., as it is not subject to putrefaction or fermentation, nor destroyed by heat. It being a very poor conductor of heat the highest useful effect can be attained; it adheres well and is very durable.

(*g*) Felt, cork waste, mineral wool either made into suitable forms and attached to the pipe, or filled into a casting surrounding the pipe, and with or without an air space about the pipe, are much used for the above purpose.

BOOK-BINDING AND BOOK REPAIRING.

BY "binding" a book is meant the arrangement of the "sheets" composing it, with maps, plates, etc., in proper sequence, within a pair of covers, of various material, with or without ornamentation, and in such a manner that the pages can be turned over separately without being detached. The art is divided into a number of operations.

Folding.—The first step is to fold the printed sheets evenly, by laying them on a table with the "signatures" (figures or letters on the first page of each sheet) at the left side facing downwards. The sheet is folded over from right to left, carefully placing the "folios" (numbers of the pages) together, and held so while the folding-stick, carried in the right hand, is drawn across the sheet, creasing the centre. Next the folder is held where the new crease is to be made, and the top half is folded downwards in the same even manner. This order is repeated till the sheet assumes the form of a page.

Books that have already been folded, and issued in numbers, must be "pulled to pieces" or divided before binding. The parts being arranged in order, the outside wrappers are torn away, and each sheet is pulled out singly, cutting any thread used in sewing the centre of the sheet at the back. Even if the sheets have not been properly done in the first instance, refolding is not often resorted to, the previous creasing rendering the paper liable to be torn; books that have been bound and cut would be rendered worse by refolding. The edge of each sheet (from a folded work) being cleared of all adhering glue, etc., the book is ready for the next process. In large establishments folding is done by machine. A very useful auxiliary to hand folding is a revolving table carrying the sheets in succession before the gatherers.

Beating and Rolling.—The object of these processes is to make the book solid. Use is made of a stone or iron slab, perfectly smooth, and bedded with great solidity; and a bell-shaped hammer, weighing about 10 lb., with a short handle fitting the hand. The faces of both hammer and "stone" must be kept clean, and it is well to lay a piece of paper above and below the "sections" when beating, or the repeated concussion will glaze them. Each "section" or lot should be about ½ in. thick, that will be 15–20 sheets, according to the thickness of paper. The section is held between the fingers and thumb of the left hand resting on the stone; the hammer, grasped firmly in the right hand, is raised and brought down with rather more than its own weight on the section, which is continually moved round, turned over and changed about, in order that it may be equally beaten all over. By passing between the fingers and thumb, it can be felt whether it has been properly and evenly beaten. In each blow of the hammer, the face must fall fairly on the body of the section; if the hammer is used so that the greatest weight falls outside the edge of the sheets, the paper will break away as if cut. After each section has been beaten, the whole are put together and beaten again.

Rolling sometimes replaces beating. But all books should not be rolled, and it is essential to know how and when to use the beating hammer, and when the rolling machine. Old books should on no account be rolled. The early printing presses exerted such pressure on the type that the paper round the margins is often 2 or 3 times as thick as the printed portion. For modern work, the rolling machine is, as a rule better than the hammer.

For rolling the book is also divided into sections but fewer sheets are taken —from 6 upwards according to the quality of the work. The sheets are placed between tins, and the whole passed under a roller, which is adjusted to the thickness of the sections and the power required, by a screw provided for the purpose. Some binders execute rolling, at a small charge, for others.

Collating.—Each sheet or leaf must be put in its proper sequence, according to the "signatures." Plates are trimmed or cut to the proper size before being placed in the book; and maps that are to be folded must be put on "guards." A map mounted on a guard of the size of the page may be kept laid open on the table beside the book, which can be read at any part without concealing the map; this is called "throwing-out" a map.

For collating, the book is held in the right hand, at the right top corner, a turn of the wrist bringing the back to the front. The sections are fanned out and with the left hand brought back to an angle, which will cause them, when released, to spring forward, so that the letter on the right bottom corner of each sheet is seen and released in succession. The book must always be beaten or rolled before placing plates or maps, especially if they are coloured.

After ascertaining that the letterpress is perfect, the plates are collated and squared with a sharp knife and straight-edge. If printed on paper larger than the book, the plates must be cut down to the book size, leaving less margin at the back than there will be at the fore-edge when the book is cut. Frontispiece plates face to the left; but as a general rule, plates should be placed on the right hand, so that on opening the book they face upwards. With plates at a right-angle to the text, the inscriptions are placed on the right margin, whether the plate faces to the right or left. Plates on thick paper must be "guarded," either by adding a piece of paper of the same thickness, or by cutting a piece off the plate and rejoining with a strip of linen, so that the plate works on a linen hinge. The width between the guard and the plate must equal the thickness of the paper. Cardboard plates are strengthened by putting linen at both back and front. If a book consist of plates only, sections may be made by placing 2 plates and 2 guards together, and sewing through the centre between the guards, leaving a space between the guards to form the back.

Maps are best mounted on the finest linen (which takes up the least room in thickness), cut a little larger than the map, with an additional piece left, on which to mount the extra paper, which throws the map out. The latter is trimmed at its back first, then brushed with rather thin paste; the pasting-board being removed, the linen is laid on, gently rubbed down, and turned over, so that the map comes to the top; the white paper is then placed a little away from the map, and the whole is well rubbed down, and finally laid out flat to dry. The paste must be clean, free from lumps, and used very evenly and moderately. The map, when dry, is trimmed all round, and folded to its proper size—a little smaller than the book will be when cut.

With all folded maps or plates, a corresponding thickness must be placed in the backs where the maps go, or the fore-edge will be thicker than the back. Pieces of paper called guards, folded ¼-1 in. in width, according to the size of the book, and placed in the back, are sewn through as a section; but care must be taken that the guards are not folded so large as to overlap the folds of the map, or the object of their being placed there will be defeated. It is easy to ensure the pasting being straight along the edge of a paper plate by placing a strip of waste paper to mark the limit and receive the spreading of the brush.

Having placed the plates, go through them again when dry, see that they adhere properly, and break off or fold them over up to the pasting, with a folding-stick, so that they will lie flat when the book is open. Coloured plates should be looked after during the whole of binding, especially after pressing. The gum on their surfaces may cause them to stick to the letter-press; in this case do not try to tear them apart, but warm a polishing iron, and pass it over the plate and letter-press, laying a piece of paper between the iron and the book to avoid dirt. The heat and moisture will soften the gum, and the surfaces can then be very easily separated. Rubbing a little powdered French chalk over the coloured plates before sticking them in, acts as a preventive.

If a book is entirely composed of single leaves, it should be collated properly and the plates placed in their places, squared and broken over, by laying a straight-edge about ½ in. from the back edge, and running a folder under each plate, thus lifting it to the edge of the runner. The whole book is then pressed for a few hours and taken out; the back, previously roughed with the side edge of a saw, is glued up, thus. The book is put into the laying press between boards, with the back projecting about ⅛ in.; the side edge of the saw is then drawn over it, so that the paper is rasped; the back is then sawn in properly, as explained in the next section, and the whole back is glued. After drying, the book is separated into "sections" of 4, 6, or 8 leaves, according to the thickness of the paper, and each section is then "overcast" or "over sewn" along its whole length. The thread being fastened at the head and tail (top and bottom), each section is made independent of the others. The sections are then (2 or 3 at a time) gently struck along the back edge with a hammer against a knocking-down iron, to imbed the thread in the paper, or the back would be too thick. Having placed the plates, the book is put into the press for a few hours, when it will be ready for "marking up" if for flexible sewing, or for "sawing in," if for ordinary work. The presses used by bookbinders are called "standing" and "laying," the latter name being obviously a corruption of "lying."

For interleaving writing paper between the leaves of letter-press, the book must be properly beaten or rolled, and each leaf cut up with a hand-knife, both at the head and fore-edge; the writing paper is then folded to the size of the book and pressed. A single leaf of writing paper is fastened in the centre of each section, and a folded leaf is placed to every folded letter-press leaf, by inserting the one within the other, leaving to every other section a folded writing paper outside, putting them all level with the head; the whole book is finally well pressed.

Fig. 61 illustrates methods of inserting guards: in A, *a* is the guard, *b* the linen hinge, and *c* the plate; in B, *a* are the guards, covered on each side with linen, and *b* are the plates, the dot between the guards indicating where the sewing through takes place; in C, which is B closed, are the linen-covered guards, and *b* the plates.

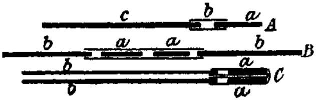

FIG. 61.

Marking up and Sawing in.—After having been for a night in the press, the book is again collated, knocked straight at both head and back, and put into the laying press between boards, projecting beyond them about ⅛ in. The boards are held between the fingers of each hand, and the back and head are knocked alternately on the cheek of the press; the boards being then withdrawn the required distance from the back of the book, the book and boards are held tightly with the left hand, and the whole carefully lowered into the press, the right hand being employed to screw up tightly, holding the book quite straight, and firmly.

If the book is to have "flexible" binding, it is not sawn in, but marked, the difference being that the cord is outside the sheets, instead of being imbedded in the back in a groove made by the saw.

For the flexible binding of an ordinary 8vo volume, to be cut all round, the back is divided into 6 equal portions, leaving the bottom or "tail" ½ in. longer than the rest, to accommodate an optical illusion, by which, if the spaces were all equal, the bottom one would appear to be the smallest. The marks on the back are exactly squared, and marked pretty black with a lead pencil. The head and tail are next sawn in to imbed the chain of the kettle-stitch, at a sufficient distance to prevent the thread being accidentally divided in cutting. Great accuracy is absolutely necessary in flexible work, especially in the marking up, as the bands on which the book is sewn remain visible after covering. A very small book, such as a prayer-book, is marked up for 5 bands, but only sewed on 3, the other 2 being fastened on as false bands when the book is ready for covering.

A book that is to be "sawn in" is marked up as for flexible work, but the back is sawn, both for the bands and "kettle-stitch," with a tenon saw, having the teeth not spread out too much, and of suitable width of cutting face. The cut must not enter too deeply, and must in all cases be guided by the thickness of cord to be used. The size of the book determines the thickness of the cord; suitable kinds can be purchased, being known by the size of the book as 8vo, 4to, etc. Loose cording causes great inconvenience, and necessitates puting a lot of glue into the grooves to keep the cord in place. On the other hand if the saw-cuts are not deep enough, the cord will stand out from the back, and be seen when the book is finished, if not remedied by extra pieces of paper between the bands when lining up. Double thin cord is better than single thick for large books, because thin cords will imbed themselves in the back, whereas a large one will not, unless very deep and wide saw cuts be made. Large folios should be sawn on 6 or 7 bands, but 5 is the right number for an 8vo, from which all other sizes can be regulated.

Sewing.—The "sewing press," Fig. 62, consists of a bed *a*, 2 screws *b*, and a "beam" or crossbar *c*, round which are fastened 5 or more "lay cords" *d*; 5 pieces of cord cut from the ball, in length measuring about 4 times the thickness of the book, are fastened to the lay cords by slip knots, the other ends being fastened to small pieces of metal called "keys" *e*, by twisting the ends round twice and then making a "half hitch." The keys are passed through the slot *f* in the bed of the "press," and the beam is screwed up loose enough to allow the lay cords to move freely backwards or forwards. The book being on the bed of the press, with the back towards the sewer, a few sheets are laid against the cords, and exactly to the marks made on the back of the sections; when quite true and perpendicular, they are tightened by screwing the beam up. If the cords are a little to the right the sewer can get his left arm to rest better on the press.

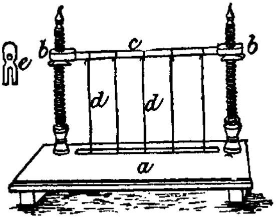

FIG. 62.

Fig. 63 represents the course of the thread in sewing the sheet to the bands; *a* being the back of the book, *b* the thread, and *c* the cord, an arrow indicating the direction of the thread.

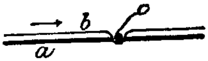

FIG. 63.

The first and last sections are strengthened by overcasting with cotton. The first sheet is laid against the bands, and the needle is introduced through the kettle-stitch hole on the right (head) of the book; the left hand being inside the centre of the sheet, the needle is taken with it, and thrust out on the left of the mark made for the first band; the needle is taken in the right hand, and again introduced on the right of the same band, thus making a complete circle round the band, This is repeated with each succeeding band, and the needle is finally brought out of the kettle-stitch hole on the left (tail) of the sheet. Another sheet is placed on the top, and similarly treated, by introducing the needle at the left end (tail); and when taken out at the right end (top), the thread is fastened by a knot to the end, hanging from the first sheet, which is left long enough for that purpose. As a thread is used out, another is joined to it, making it continuous; the knots must be made very neatly, and the ends cut off. A third sheet having been sewn like the others, the needle is brought out at the kettle-stitch, thrust between the two sheets first sewn, and drawn round the thread, thus securing each sheet to its neighbour by a kind of chain stitch. This is the strongest way of sewing, and takes 3 or 4 times as long as ordinary sewing. The thread must be drawn tight each time it passes round the band, and finally properly fastened off at the kettle-stitch, or the sections will work loose in time. The cord for flexible work is called "flexible"; it is twisted tighter and is stronger than any other, Marshall's being the best. The thickness of the cord must be proportioned to the size and thickness of the book, and will partly depend on whether the sheets are halves or wholes. Too thick a thread will make the "swelling" (the rising caused in the back by the thread) too much and prevent a proper rounding and a right sized "groove" in backing. With thick or few sections, a thick thread must be used to produce a good groove.

In a book of moderate thickness, the sections may be knocked down by occasionally tapping them with a piece of wood loaded at one end with lead, or with a thick folding-stick. In the kettle-stitch, the thread must not be drawn too tight in making the chain, or the thread will break in backing; nor left too slack, or the sheets will wear loose. The last sheet should be fastened with a double knot round the kettle-stitch, 2 or 3 sections down, and that section must be sewn all along.

Ordinary sewing differs in that the thread is not twisted round the cord. The cord fits into the saw cuts; the thread is passed over the cord, not round it, and then along the section, out of the holes made, and into them again, the kettle-stitch being made in the same way. In this style, the back of the book can be better gilt: in flexible work, the leather is pasted to the back, and is bent each time the book is opened, incurring a risk of the gold breaking away from the leather in wear. Books sewn in the ordinary method are made with a hollow back, and when the book is opened, the crease in the back is independent of the leather covering, so that the lining of the back only is creased, and the leather keeps its form because the lining gives it a spring outwards. Morocco leather is always used for flexible work. Ordinary sewing is adapted for books that do not require great strength, such as library bindings; but a book for constant reference or daily use should be sewn flexibly.

In the method called "flexible not to show," the book is marked up in the same way as for flexible, and is slightly scratched on the band marks with the saw, but not deep enough to go through the sections. Then a thin cord is doubled for each band, and the book is sewn in the ordinary flexible way. The cord is knocked into the back in forwarding, and the leather may be stuck on a hollow back with bands, or to the back itself without bands.

Very thin sections, or half sheets, if the book is very thick, may be sewn "2 sheets on," i.e. the needle is passed from the kettle-stitch to the first band of the first sheet and out, then another sheet is placed on the top, and the needle is inserted at No. 1 band and brought out at No. 2; the needle is again inserted in the first sheet and in at No. 2 band and out at No. 3, thus treating the two sections as one, in which way, obviously only half as much thread will be in the back. With books that have had the heads cut, it is necessary to open each sheet carefully up to the back before it is placed on the press, otherwise the centre may not be caught, and 2 or more leaves will fall out after the book is bound.

Books composed of single leaves are overcast, and each section is treated as a section of an ordinary book, the only difference being that a strong paper lining should be given to the back before covering so that it cannot "throw up." As already detailed for volumes of maps and plates.

Forwarding.—For "end" papers, the coloured paper is pasted on white, the style of binding deciding the choice. The usual kinds are as follows.

"*Cobb*" paper (used generally for half-calf bindings with sprinkled edge, or half-calf gilt top) is stained various shades and colours in the making, brown or sage green being the colours most favoured.

"*Surface*" paper has one side prepared with a layer of colour, laid on with a brush very evenly; some kinds are left dull, others are glazed. Darker colours are generally chosen for religious books, and lighter for cloth or case work. Many other kinds are put into "extra" bindings with good effect e.g. a cream of fine colour and good quality in a morocco with cloth or morocco joints.

"*Marbled*" paper has colours disposed on it in imitation of marble, produced by sprinkling prepared colours upon a coating of size made from an emulsion or resinous solution. *See* "MARBLING."

"*Printed*" and "*fancy*" papers may be bought in any variety. "Coloured paste" paper may be home-made. Some colour is mixed with paste and soap till it is a little thicker than cream, then spread upon 2 sheets of paper with a paste-brush; the sheets are next laid with their coloured surfaces in contact, and when separated will bear a wavy pattern. The paper is hung up till dry, and glazed with a hot iron.

Having decided upon the kind of paper to use, cut and fold 2 pieces to the size of the book, or a trifle larger especially if the book has been already cut; also prepare 2 pieces of white paper in the same way. This done a white paper is laid down, folded, and very evenly brushed with moderately thin paste; the 2 fancy papers are laid on the top, level with the back or folded edge; the top fancy paper is pasted and the other white is laid on that; next take them from the board and after a squeeze in the press, hang them up separately to dry. Thus one half of the white will adhere to one half of the marbled or fancy paper. When dry, they are folded in the old folds and pressed for ½ hour. As many as 10–15 pairs may be done at once, by commencing with 1 white, then 2 fancy, 2 white, and so on, always pressing, to ensure the surfaces adhering properly, then hanging up to dry, and when dry, pressing again, to make them quite flat.

In pasting be sure to draw the brush well over the paper and away from the centre, towards the edges of the paper. Take just enough paste on the brush to make it slide well. See that the whole surface is pasted; remove all hairs and lumps from the paper, or they will mark the book; and never attempt to take up the brush from the paper before it is well drawn over the edge, or the paper will stick to the brush and turn over, with the risk of pasting the under side.

Pasting up.—In every book, the first and last sheet, which have been overcast as instructed, must be "pasted up"; and if the book has too much "swelling," it must be tapped down gently with a hammer, holding the book tightly at the fore-edge with the left hand, knuckles down, and resting the back on the press. A better plan is for the back to be knocked flat on the laying press, placed in it without boards, so that the back projects, screwed up tightly, so that the sheets cannot slip; a knocking-down iron is then placed against left side of the book and the back is hammered against it. The "slips" or cords are pulled tight, each with the right hand, the left hand holding them against the book so that they shall not be drawn through. The process is illustrated in Fig. 64: *a*, press; *b*, knocking-down iron; *c*, book.

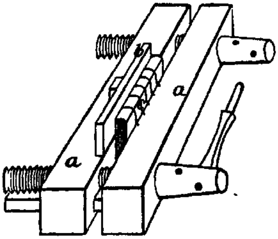

FIG. 64

Pasting on the End Papers.—For each side of the book, a single leaf of white paper, somewhat thicker than that used for the ends, is cut. Lay the end papers on a board or on the press, with the pasted side uppermost, and put the single leaves on the top. Fan them out evenly to a proper width (about a ¼ in. for an 8vo), lay a piece of waste paper on the top, and paste their edges. Having thrown the slips back, the white flyleaf is put on the book, a little way from the back, the made ends on the top are placed even with the back, and the book is again left to dry beneath a weight.

Very heavy or large books should have bookbinders' cloth or leather "joints" matching the colour of the cover, morocco being mostly used for leather joints. Cloth joints may be added either when the ends are being put on, or when the book is ready for pasting down. Now the cloth is cut 1–3 in., according to the size of the book, and folded quite evenly, leaving the side of the cloth to go on the book the width intended to be glued; thus a width of 1 in. should be folded ¾ on one side, leaving ¼ on the other, and putting the ¼ on the book. Having glued the smallest fold, the white flyleaf is put on, and the fancy paper on the top. The difference here is that the paper is single, or is cut to the size of the book and pasted all over. It is best to paste the marble paper, put on the white, rub well down, and lay them between millboards to dry. Finally a piece of waste or brown paper may be slightly fastened at the back over the whole, turning the cloth down on the book to keep it clean and prevent injury.

When the cloth joint is to be put on after the book is covered, the flyleaves and ends are only edge-pasted to the book just to hold them while it is being bound; when the book is to be pasted down, the ends are lifted from it by running a thin folding-stick between the ends and the book. The cloth is cut and folded as before, fastened on, and the ends and flyleaves are properly pasted in the back. Morocco joints are always put in after the book is covered.

Cloth joints go in better at the same time as the ends, taking care that the ends are quite dry after being made before attaching them, or their dampness will cause wrinkles.

The ends being quite dry, the slips are unravelled and scraped with a bodkin and a knife-back, so that they may with greater ease be passed through the holes in the millboard, and the cord be more evenly distributed and beaten down, to prevent their being seen in the covered book.

Trimming.—If the book is to be uncut, or to have a gilt top, the rough edges are "trimmed" off with a very sharp knife or shears. The book is knocked up straight, laid on a smooth-planed "trimming board," and compassed from the back as a guide; a straight-edge is laid on the compass holes, and the fore-edge is cut. The object being merely to make the edges true, only the rough and dirty edges are taken off, leaving the book as large as possible. Sometimes the book is put into the cutting press, and the overplus is taken off with a "round plough," especially if a number of books are to be done together. It is better to use the straight-edge and knife for the fore-edge and tail, and to cut the top when the boards are on the book.

Glueing up.—Glue is now applied to the back to hold the sections together, and make the back firm during the rounding and backing. Knock the book perfectly true at its back and head, and put it into the laying press between 2 pieces of old millboard; expose the back, and let it project from the boards a little, the object being to hold the book firm and to keep the slips close to the sides, so that no glue shall get on them; then with glue, not too thick, but hot, glue the back, rubbing it in, and taking the overplus off again with the brush.

A handful of shavings is sometimes used to rub the glue in, and take the refuse away, but a great quantity of glue is thus wasted. The Germans rub the glue in with the back of a hammer, and take away the overplus with the brush; this is better than using shavings. The back must not be allowed to get too dry, before it is rounded, or it will have to be damped with a sponge, to give the glue the elasticity required, but being wet is worse than letting it get too dry. The book should be left for about an hour, or till it no longer feels tacky to the touch, but still retains its flexibility. A flexible bound book should be rounded first, using a backing board to bring the sheets round, instead of a hammer; then the back is glued, and a piece of tape is tied round the book to prevent its going back flat.

All books are not glued up in the press; some workmen knock up a number of books, and, allowing them to project a little over their press, glue the lot up at once; others, again, hold the book in the left hand, and draw the brush up and down the back. These last methods are, however, only practised in "cloth shops," where books are bound or cased at very low prices. The proper way is to put the book in the press; and if more than one, they should be laid alternately back and fore-edge, with the back projecting about ½ in., and allowed to dry spontaneously, on no account being dried by the heat of a fire, as all artificial heat in drying in any process of bookbinding is injurious to the work.

Rounding.—"Rounding" applies to the back of the book, and is preliminary to backing. In rounding the back, the book is laid on the press before the workman with the fore-edge towards him, and held with the left hand by placing the thumb on the fore-edge and fingers on the top of the book pointing towards the back, so that by drawing the fingers towards the thumb, or by pressing fingers and thumb together, the back is drawn towards the workman at an angle. The back is then struck gently with the flat or face of the hammer, beginning in the centre of the back, still drawing the back over with the left hand. The book is then turned over, the other side is treated in the same way, and so continually changed or turned until it has its proper form, which should be about ⅓ of a circle. When sufficiently rounded, it is examined to see if one side be perfectly level with the other, by holding the book up and glancing down its back, and gently tapping the places where uneven, until it is perfectly uniform. The thicker the book, the more difficult to round it; and some papers will be found more obstinate than others, so that great care must be exercised both in rounding and backing, as the fore-edge when cut will have exactly the same form as the back.

Backing. — "Backing - boards" should be rather longer than the book, somewhat thicker than cutting-boards, and with their tops planed at an angle, so that the sheets may fall well over. Hold the book in the left hand, lay a board on one side, a little away from the back, taking the edge of the top sheet as a guide, the distance to be a trifle more than the thickness of the boards to be used. The book, with the backing-board is then turned over, holding the boards to the book by the thumb, so that it does not shift; next lay the other board at exactly the same distance on the other side. The whole is now held tightly by the left hand, and lowered into the press. The boards may possibly have shifted a little during the process, and any correction may now be made whilst the press holds the book before screwing up tight, such as a slight tap with the hammer to one end of a board that may not be quite straight. Should the boards however be not quite true, it will be better to take the whole out and readjust them, rather than lose time in trying to rectify the irregularity by any other method.

The book and boards being lowered flush with the cheeks of the press, screw it up as tightly as possible with the iron hand-pin. The back of the book must now be gently struck with the back of the hammer, holding it slanting, and beating the sheets well over towards the backing-boards. Commence from the centre of the back and do not hit too hard, or the dent made by the hammer will show after the book has been covered. The back is finished with the face of the hammer bringing the sheets well over on the boards so that a good and solid groove may be made. Each side is to be treated in the same way, and have the same amount of weight and beating. The back must receive a gradual hammering, and the sheets when knocked one way must not be knocked back again. The hammer should be swung with a circular motion, always away from the centre of the back. The book, when opened after backing, should be entirely without wrinkles. Backing and cutting constitute the chief work in forwarding, and if these are not done properly, the book cannot be square and solid—great essentials in bookbinding.

Backing flexible work is a little more difficult, as the slips are tighter; otherwise the process is exactly the same, only care must be taken not to hammer the cord too much, and to bring over the sections very gently, in order not to break the sewing thread.

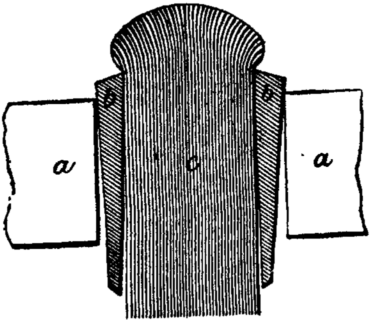

FIG. 65.

Fig. 65 illustrates a section of a book in the press before backing; *a*, press; *b*, backing-boards; *c*, book. Fig. 66 represents a section of the same book in the press after backing.

Millboards. — The workman should take advantage of the period of drying to select the proper thickness of boards, and line them with paper on one side or both.

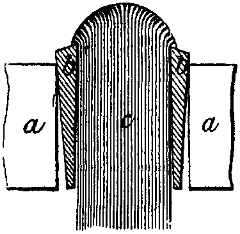

FIG 66.

First square the edge which is to go to the back of the book, in the cutting press, using a cutting-board for one side termed a "runner," and another called a "cut-against" for the other side. These are to save the press from being cut; and a piece of old millboard is generally placed on the cut-against, so that the plough-knife does not cut up the latter too quickly. The boards, if for whole-binding, are lined on both sides with paper; if for half-binding, on one side. The reason for lining is to make the boards curve inwards towards the book. The various pastings would cause the board to curve the contrary way if it were not lined. It may be taken as a general rule that a thinner board when pasted will always draw a thicker one. If the boards are lined on both sides, paper is cut double the size of the boards; if on one side, the paper is cut a little wider than the boards, so that a portion of it may be turned over on to the other side about ¼ in. The paper is brushed with not too thick paste, and the board is laid on the paper with the cut edge towards the portion to be turned over. It is now taken up with the paper adhering, laid on the press with the paper side upwards, and rubbed well down; again turned over, and the paper drawn over the other side. Press the boards so as to be quite sure that the paper adheres.

When books are very thick, 2 boards may be stuck together, not only to get the proper thickness but for strength. If a board has to be made, a thick and a somewhat thinner board should be put together. Paste both boards, and put them in the standing press for the night. Great pressure should not be put on at first, but after allowing them to set for a few minutes, pull down the press as tight as possible. When putting made boards to the book, the thinner one should always be next the book.

When boards are lined on one side only, it is usual to turn ½ in. of the paper over the square edge, and the lined side must be placed next the book.

There are many kinds of boards made. Black boards made of old rope vary much in quality, but the blacker, harder, and smoother they are the better. The grey or white boards, used mostly for antique work, are pasted on a thin black board, and bevelled down to the black one to the required width and angle. The boards used extensively for clothwork are yellow and are made from straw, or from wood-pulp. All boards are sold by weight, no matter what size or thickness.

The most useful implement for cutting the boards up are large shears. One arm or shank is screwed into the laying press, and the other, left free, is used with the right hand; the left hand holds the board to be cut.

Boards, when lined, are laid out to dry, and when dry, cut to the size of the book. The requisite width is obtained by extending the compasses from the back of the book to the edge of the smaller bolt or fold in the fore-edge. After screwing them up, the boards are knocked up even, compassed up, and cut in the laying press, using as before, the "cut-against," and placing the runner exactly to the compass holes. When cut, they are tested by turning one round and putting them together again; if they are the least out of truth, it will be apparent at once. The "head" or top of the boards is next cut by placing a square against the back, and marking the head with a bodkin. The boards being quite straight are again put into the press and cut, and when taken out should be again proved by reversing them as before; if not true, they must be recut. The length is taken from the head of the book to the tail, and in this some judgment must be used. If the book has already been cut, the boards must be somewhat larger than the book, leaving only such an amount of paper to be removed as will make the edge smooth. If, however, the book is to be entirely uncut, the size of the book is taken, and the portions called "squares" that project round the book, in addition.

When a book has not been cut, the amount to be cut off the head will give the head or top square, and the book being measured from the head, another square or projection must be added to it, and the compass set to one of the shortest leaves in the book. Bearing in mind the section on trimming, enough of the book only should be cut to give the edge solidity for either gilding or marbling. A few leaves should always be left not cut with the plough, to show that the book has not been cut down. These few leaves are called "proof," and are always a mark of careful work.

Drawing-in and Pressing.—The boards having been squared, they are attached to the book by lacing the ends of the cord through holes in the board. The boards are laid on the book with their backs in the groove and level with the head; they are then marked with a pencil or bodkin exactly in a line with the slips, about ½ in. down the board. Holes are next made in the board with a short bodkin (with a piece of wood beneath) on the line, at a distance from the edge in accordance with the size of the book. About ½ in. away from the back is the right distance for an octavo. The board is turned over, and a second hole is made about ½ in. away from the first ones. The boards having been holed, the slips are scraped, pasted slightly, and tapered or pointed. Draw them tightly through the hole first made, and back through the second. Tap them slightly when the board is down, to prevent them from slipping and getting loose. When the books are drawn-in, cut the ends of the slips close to the board with a knife, and well hammer them down on the knocking-down iron to make the board close on the slips and hold them tight. The slips should be well and carefully hammered, as any projection will be seen with great distinctness when the book is covered. The hammer must be held perfectly even, or the slips will be out by the edge.

The book is now examined, and any little alteration may be made before putting it into the standing press. Pressing-boards the same size as the book, should be put flush with the groove, and in the centre of the press directly under the screw, which is tightened as much as possible. With all good books, a tin is put between the millboard and book, to flatten the slips and prevent their adherence to the book. The tin is put right up to the groove, and serves also as a guide for the pressing-board. In pressing books of various sizes, the largest is put at the bottom of the press, with a block or a few pressing-boards between the various sizes, in order to get equal pressure on the whole and to allow the screw to come exactly on the centre of the books.

The backs of the books are pasted and allowed to stand for a few minutes to soften the glue. Then with a piece of wood, called a "cleaning-off" stick, the glue is rubbed off, and the backs are well rubbed with a handful of shavings and left to dry. Let them lie as long as possible in the press, and, if the volume is rather thick, a coat of paste should be applied to the back.

In flexible work care must be taken that the cleaning-off stick is not forced too hard against the bands, or the thread, being moist, will break; or the paper, being wet, will tear; or the bands may be shifted. The cleaning-off stick may be made of any piece of wood; an old octavo cutting-board is good.

When the volume has been pressed enough (at least 8 hours) it is taken out and the tins and boards are put away. The book is then ready for "cutting."

Cutting.—All cutting "presses" are used in the same way: the plough runs over the press, and its left cheek runs between 2 guides fastened on the left cheek of the press. By turning the screw of the plough, the right cheek is advanced towards the left; the knife fixed on the right of the plough is advanced, and, with the point, cuts gradually through the boards or paper secured in the press, as already described in preparing the boards. There are 2 kinds of plough in use—in one the knife is bolted, in the other the knife slides in a dovetail groove—termed respectively "bolt knife" and "slide knife." The latter is preferable, on account of its facility of action, as any length of knife can be exposed for cutting. A bolt knife being fixed to the shoe of the plough, is necessarily a fixture and must be worn down by cutting or squaring millboards, or such work, before it can be used with the truth necessary for paper.

To cut a book properly, it must be quite straight, and the knife must be sharp and perfectly true. Having this in mind, the book may be cut by lowering the front board the requisite distance from the head that is to be cut off. A piece of thin millboard or "trindle" is put between the hind board and the book, so that the knife when through the book may not cut the board of the book. The book is now lowered into the cutting-press, with the back towards the workman, until the front board is exactly on a level with the press. The head of the book is now horizontal with the press, and the amount to be cut off is exposed above it. Both sides should be looked to, as the book is very liable to get a twist in being put in the press. When it is quite square, the press is screwed up tightly and evenly. Each end should be screwed up to exactly the same tightness; if one end is loose, the paper will be jagged or torn instead of being cut cleanly.

The book is cut by drawing the plough gently to and fro; each time it is brought towards the workman, a slight amount of turn is given to the screw of the plough. If too much turn is given to the screw, the knife will bite too deeply into the paper, and will tear instead of cutting it. If the knife has not been properly sharpened, or has a burr upon its edge, it will be certain to cause ridges on the paper. The top edge being cut, the book is taken out of the press and the tail is cut. A mark is made on the top of the hind or back board just double the size of the square, and the board is lowered until the mark is on a level with the cut top. The book is again put into the press, with the back towards the workman, until the board is flush with the cheek of the press; this will expose above the press the amount to be taken off from the tail, as before described, and the left-hand board will be, if put level with the cut top, exactly the same distance above the press as the right-hand board is below the cut top. The tail is cut in the same way as the top edge.

To cut a book properly requires great care. Always lay a book down one way and take it up another, and in cutting always work with the back of the book towards you, and cut from you. Give the turn to the screw of the plough as it is thrust from you, or you will pull away a part of the back instead of cutting it.

In cutting the fore-edge, always have the head of the book towards you, so that if not cut straight you know exactly where the fault lies. The fore-edge is marked at both back and front of the book by placing a cutting-board under the first 2 or 3 leaves as a support; the millboard is then pressed firmly into the groove, and a line is drawn or a hole is pierced at head and tail, using the fore-edge of the board as a guide. The book is now knocked with its back on the press quite flat, and "trindles" (flat pieces of steel in the shape of an elongated U, about 1½ in. wide and 3–4 in. long, with a slot nearly the whole length), are placed between the boards and book by letting the boards fall back from the book, and then passing one trindle at the head, the other at the tail, allowing the top and bottom slip to go in the grooves of the trindles. The object of this is to force the back up quite flat; by holding the book when the cut-against and runner are on it, supported by the other hand under the boards, it can be seen if the book is straight. The cut-against must be put quite flush with the holes on the left of the book, and the runner the distance under the holes that the amount of square is intended to be. The book being lowered into the press, the runner is put flush with the cheek of the press, and the cut-against just the same distance above the press as the runner is below the holes. The trindles are taken out from the book when the cutting-boards are in their proper place; the millboards will then fall down. The book and cutting-boards must be held very tightly, or the book will slip. If the book has been lowered into the press accurately, everything will be quite square. The press is screwed up tightly, and the fore-edge is ploughed; when the book is taken out of the press, it will resume its original rounding, the fore-edge will have the same curve as the back, and if cut truly there will be a proper square all round the edges. This method is known as "cutting in boards."

If the workman has a set of some good work which he wishes to bind uniformly, but which has already been cut to different sizes, and he does not wish to cut the large ones down to the smaller size, he must not draw the small ones in, as he may possibly not be able to pull his boards down the required depth to cut the book, so he must leave the boards loose, cut the head and tail, then draw the boards in, and turn up and cut the fore-edge.

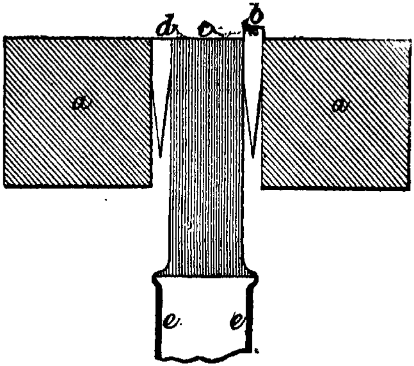

FIG. 69

"*Cutting out of boards*" is by a different method. The fore-edge is cut before glueing up, taking the size from the case, if for casing, from the back to the edge of the board in the fore-edge. The book is glued up, rounded, and put into the press for ½ hour, just to set it. The size is again taken from the case, allowing for squares at head and tail. The book, having been marked, is cut, and then backed. Cloth cases are made for most periodicals, and may be procured from their publishers at a trifling cost, which varies according to the size of the book and the amount of blocking that is upon them.

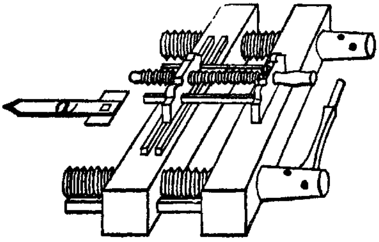

FIG. 67.

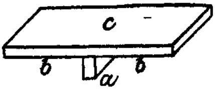

FIG 68

Fig. 67 illustrates the cutting-press, *a* being the knife. Fig. 68 shows the knocking-down iron: the flange *a* is secured between the cheeks of the press; the sides *b* rest on the press; and the boards are hammered on the smooth face *c*. Fig. 69 is an ideal section of the cutting-press, representing the cutting of a fore-edge of a book; *a*, jaws of press; *b*, cut-against; *c*, fore-edge of book; *d*, runner; *e*, boards of book.

Colouring the Edges.—The edges of a book should be in keeping with the binding. A half-roan book should not have an expensive edge, nor a whole bound morocco book a sprinkled edge. Taste is the only guide.

Sprinkling Edges.—(*a*) Take an old

toothbrush and dip it into a coloured ink; shake off the superfluous ink, that the sparks formed may not be too large, and draw an old comb through it in such a manner as to make the ink fly off in sparks over the edges of the book. The following are a few coloured inks: Red; ¼ lb. of the best logwood is boiled with 1 oz. of pounded alum, and the same quantity of cream of tartar, with half the quantity of water, and, while the preparation is still warm, 1 oz. of sugar and 1 oz. gum arabic are dissolved in it. Blue; solution of indigo with pieces of alumina, and mixed with gum, forms a blue ink. Green; this is obtained from verdigris, distilled with vinegar, and mixed with a little gum. Yellow; saffron, alum, and gum water form a yellow.

(*b*) Most shops have a colour, usually a reddish-brown, which they use for all sprinkled edge books; it can be purchased at any oil shop. A mixture of burnt umber and red-ochre is generally used; the 2 powders are well mixed in a mortar with paste, a few drops of sweet oil, and water. The colour may be tested by sprinkling some on a piece of white paper, allowing it to dry, and burnishing. If the colour powders or rubs, it is either too thick, or has not enough paste in it. If the former, some water must be added; if the latter, more paste. It will be better if the whole is passed through a cloth to rid it of any coarse particles.

Books may be sprinkled so as to resemble a kind of marble by using 2 or 3 different colours. For instance, the book is put in the laying press, and a little sand is strewn upon the edge in small mounds. Then with a green colour a moderate sprinkle is given. After allowing it to dry, more sand is put on in various places, a dark sprinkle of brown is put on, and the whole is allowed to dry. When the sand is shaken off, the edge will be white where the first sand was dropped, green where the second and the rest brown.

A colour of 2 shades may be made by using sand, then a moderately dark brown sprinkled, then more sand, and lastly a deeper shade of same colour.

A few still use the "finger brush," a small brush about the size of a shaving brush, made of stiff bristles cut squarely. They dip it into the colour, and then by drawing the finger across it jerk the colour over the edge. Another method is to use a larger brush, which, being dipped in the colour, is beaten on a stick or press-pin until the desired amount of sprinkle is obtained. But the best plan for an amateur is to use a nail-brush and a common wire cinder-sifter. Dip the brush in the colour and rub it in a circular direction over the cinder-sifter. This mode has the satisfactory result of doing the work more quickly, finely and uniformly. The head, fore-edge and tail must be of exactly the same shade, and one end must not have more sprinkle on it than the other, and a set of books must have their edges precisely alike in tone and character.

Colours for Sprinkling.—Many dyes and colours that answer all purposes, may be purchased ready for instant use. Judson's dyes diluted with water are very good.

Plain Colouring.—The colours, having been well ground, are mixed with paste and a little oil, or glaire and oil. Then, with a sponge or brush, colour the whole of the edge. In colouring the fore-edge, the book should be drawn back so as to form a slope of the edge, so that when the book is opened a certain amount of colour will still be seen. It is often necessary to give the edges 2 coats of colour, and the first must be quite dry before the second tint is applied.

A very good effect may be produced by first colouring the edge yellow, and when dry, after throwing on rice, seeds, pieces of thread, or anything else according to fancy, sprinkle with some other dark colour. For this class body colour should always be used. This may be varied in many different ways.

Painted Edges.—The edge is fanned out and tied between boards, and whilst in that position some landscape or other scene, either taken from the book itself or appropriate to the subject of it, is painted on the fore-edge, and when quite dry it is gilt on the flat in the usual manner. This work of course requires an artist well skilled in water-colour drawing.

After the edges have been gilt by any of the foregoing methods, the rounding must be examined and corrected, and the book should be put into the standing press for 2-3 hours, to set it. The whole of the edges should be wrapped up with paper to keep them clean during the remainder of the process of binding. This is called "capping up."

Head-banding.—Few binders work their own head-bands; the majority use the machine-made head-band. These can be purchased of any size or colour, at a moderate price.

Head-banding done by hand is really only a twist of different coloured cotton or silk round a piece of vellum or catgut fastened to the back at every half-dozen sections. If the head-band is to be square or straight, the vellum should be made by pasting 2 or 3 pieces together. Damp the vellum previously, and put it under a weight for a few hours to get soft. Vellum from old ledgers and other vellum-bound books is mostly used. The vellum, when quite dry and flat, is cut into strips just a little under the width of the squares of the books, so that when the book is covered, the amount of leather above the head-band and the head-band itself will be just the size or height of the square.

If, however, a round head-band is chosen, catgut is taken on the same principle with regard to size, and this is further advanced by using 2 pieces of catgut, generally one being smaller than the other, and making with the beading 3 rows. To explain how the head-band is worked is a difficult task; yet the process is very simple. The great difficulty is to get the silks to lie close together, which they will not do, if the twist or beading is not evenly worked. This requires time and patience to accomplish. The hands must be clean or the silk will get soiled; fingers must be smooth or the silk will be frayed.

Supposing a book is to be done in 2 colours, red and white. The head-band is cut to size, the book is, for convenience, held in a press, or a plough with the knife taken out, so that the end to be head-banded is raised to a convenient height. The ends of the silk or cotton are joined together, and one, say the red, is threaded through a strong needle. This is passed through the back of the book, at about the centre of the second section, commencing on the left of the book, twice, and a loop is left. The vellum is put into this loop, and the silk is drawn tight; the vellum will then be held fast. The white is now twisted round the red once, and round the head-band twice; the red is next taken in hand and twisted round the white once and the head-band twice. This is done until the whole vellum is covered. The needle must be passed through the back at about every 8 sections to secure the head-band. The beading is the effect of one thread being twisted over the other, and the hand must be kept exactly at the same tightness or tension, for if pulled too tightly the beading will go underneath, or be irregular. The fastening off is done by passing the needle through the back twice, the white is then passed round the red and under the vellum, and the ends are tied together.

Three Colours Plain.—This is commenced in the same way as with 2, but great care must be taken that the silks are worked in rotation, so as not to mix or entangle them. The silks must be kept in the left hand, while the right twists the colour over or round; and as each is twisted round the vellum, it is passed to be twisted round the other two. In fastening off, both colours must be passed round under the vellum and fastened as with the 2-colour pattern.

Head-bands may be worked intermixed with gold or silver thread, or the one colour may be worked a number of times round the vellum before the second colour has been twisted, giving it the appearance of ribbons going round the head-band.

Stuck-on Head-bands may be made at little expense, by using striped calico for the purpose. A narrow stripe is to be preferred of some bright colour. The material must be cut into lengths of about 1½ in. wide, with the stripes across. Cords of different thickness are then cut somewhat longer than the calico, and a piece of the cord is fastened by a nail at one end on a board of sufficient length. The calico is then pasted and laid down on the board under the cord; the cord, being held tightly, may be easily covered with the striped calico, and rubbed with a folder into a groove.

When this is dry, the head and tail of the book are glued, and the proper piece of the head-band is put on. Or the head-band may be purchased, as before stated, worked with either silk or cotton ready for fastening on for 1*s.* to 2*s.* 6*d.* a piece of 12 yd., according to the size required. The amateur will find this far better than working his own head-bands, but it has the disadvantage of not looking so even as a head-band properly worked on the book.

After the head-band has been put on or worked, the book is "lined up" or "got ready for covering."

Preparing for Covering.—Nearly all modern books are bound with hollow backs except where the books are sewn for flexible work, or otherwise meant to have tight backs.

The head-band is first set with glue, if worked, by gluing the head and tail, and with a folder the head-band is made to take the same form as the back. This is done by holding the book in the left hand with its back on the press, then a pointed folder held in the right hand is run round the beading 2 or 3 times to form it; the silk on the back is then rubbed down as much as possible to make all level and even, and the book is allowed to dry. When dry it is put into the laying press to hold it, and the back is well glued all over; some paper, usually brown, is now taken, the same length as the book, put on the back and rubbed down well with a thick folder; a good-sized beef rib is as good as anything. The overplus of the paper is cut away from the back, except the part projecting head and tail. A second coat of glue is put on the top of the brown paper and another piece is put on that, but not quite up to the edge on the left side. When this is well rubbed down, it is folded evenly from the edge on the right side over to the left; the small amount of glued space left will be found sufficient to hold it down. The top is again glued, folded over from left to right, and cut off level by folding it back and running a sharp knife down the fold. This is what is generally termed "two on and two off," being 2 thicknesses of paper on the back and 2 for the hollow; but thin or small books need only have 1 on the back, and 2 for the hollow. Thick or large books should have more paper used in proportion to their size. Books that have been over-cast in the sewing should have rather a strong lining up, so that there be not such a strain when opened. When the whole is dry, the overplus of the paper, head and tail, is cut off close to the head-band.

The better the paper used, the easier will be the working of it. Old writing or copy-book paper will be found to be as good as any, but good brown paper is mostly used.

The book is now ready for putting the bands on. These are prepared beforehand by sticking with glue 2 or 3 pieces of leather together or on a piece of paper, well pressing, and allowing to dry under pressure. The paper must be glued twice, allowing each coat to dry before glueing again.

It should then be put on one side for future use, and when wanted, the proper thickness is chosen and cut into strips of a width to correspond with the size of the book. The book is marked up, 5 bands being the number generally used, leaving the tail a little longer than the other portions. The strips of band are then moistened with a little hot water to cause the glue upon the paper to melt. Each piece is then fixed upon the back just under the holes made with the compasses in marking up. This will be found to be a far better plan than to first cut the strips, and then glue them. By the latter plan, the glue is liable to spread upon the side, where it is not wanted, and if the book has to be covered with light calf, it will certainly be stained black: be careful that all glue is removed from the back and sides before attempting to cover any book with calf.

When dry, the ends of the bands are cut off with a bevel, and a little piece of the boards from the corners nearest the back is also taken off on the bevel, that there may not be a sharp point to fret through the leather when the book is opened. This is also necessary, so that the head-band may be properly set. A sharp knife should be inserted in the hollow, and should separate it from the back at head and tail on each side so far as to allow the leather to be turned in.

Flexible Work.—This is not lined up. The leather is stuck directly upon the book; the head-band is set as before explained, and held tight by glueing a piece of fine linen against it, and when quite dry, the overplus is cut away, and the back is made quite smooth. The bands are knocked up gently with a blunt chisel to make them perfectly straight, being first damped and made soft with a little paste to facilitate the working and prevent the thread from being cut. Any holes caused by sawing in, in previous binding, must be filled up with a piece of frayed cord, pasted. Any holes thus filled up must be made quite smooth when dry, as the least unevenness will show when the book is covered.

In "thrown up" backs, or in "flexible not to show," a piece of thin linen or stuff called "mull" (muslin) is glued on the back first, and one piece of paper on the top. For the hollow, 3, 4, or even 5 pieces are stuck one on the other, so that it may be firm; whilst the book itself will be as if it had a flexible back. The bands if any, are then fastened on, and the corners of the boards are cut off. It is then ready for covering. "Mock flexible" has generally one piece of paper glued on the back, and when marked up, the bands are put on as before, and the book is covered.

Covering.—Books are covered according to the fancy of the binder or customer. The materials used at the present day are—leather of all sorts, parchment or vellum, bookbinders' cloth, velvet, needlework, and imitation leather, of which various kinds are manufactured, such as leatherette and feltine.

Each kind requires a different manner of working or manipulation. For instance, a wet calf book must not be covered in the same manner as a velvet one.

Under the class of leather, come moroccos of all kinds; russia; calf, coloured, smooth and imitation; roan, sheep and imitation morocco.

The morocco cover, indeed any leather cover, is cut out by laying the skin out on a flat board, and having chosen the part or piece of the skin to be used, the book is laid on it and the skin is cut with a sharp knife round the book, leaving a space of about ⅝ in. for an 8vo, and more or less according to the size of the book and thickness of board, for turning in. The morocco cover should now have marked upon it with a pencil, the exact size of the book itself, by laying the book on the cover, and running the point of a black lead pencil all round it. The leather must then be "pared," or shaved round the edges, using the pencil marks as a guide. This paring process is not difficult, especially if a French knife is used, the chief point being that a very sharp edge is to be kept on the knife, and that the "burr" is on the cutting edge. The knife is held in the right hand, placing two fingers on the top with the thumb underneath. The leather must be placed on a piece of marble, lithographic stone, or thick glass and held tightly strained between finger and thumb of the left hand. Then, by a series of pushes from the right hand, the knife takes off more or less, according to the angle given. The burr causes the knife to enter the leather; if the burr is turned up, the knife will either not cut or run off. If the knife is held too much at an angle, it will go right through the leather. The leather should from time to time be examined, by turning it over, to see if any unevenness appears, for every cut will show. Special attention should be given to where the edges of the board go. The turning in at the head and tail should be pared off as thin as possible, as there will be twice as much thickness of leather on the back where turned in, the object of this care being that it must not be seen. The morocco cover should now be wetted well, and grained up by the hand or a flat piece of cork. This is done by gently curling it up in all directions; and when the grain has been brought up properly and sufficiently, the leather should be pasted on the flesh side with thin paste, and hung up to dry. Should the leather be "straight grain," it must only be creased in the one direction of the grain, or if it is required to imitate any old book that has no grain, the leather should be wetted as much as possible, and the whole of the grain rubbed out by using a rolling-pin with even pressure.

Russia and calf require no setting up of the grain, but russia must be well rolled out with the rolling-pin.

When the cover (morocco) is dry, it is well pasted, and the squares of the book are set, so that each side has its proper proportion of board projecting. The book is then laid down evenly on the cover, which must be gently drawn on; the back is drawn tight by placing the book on its fore-edge and pulling the skin well down on the back. The sides are next drawn tight, and the bands are pinched well up with a pair of "band nippers." The 4 corners of the leather are cut off with a sharp knife in a slanting direction, a little paste is put on the cut edge, and the operation of turning in may be commenced.

The book is held on its edge, either head or tail, with a small piece of paper put close to the head-band to prevent any paste soiling the edge or head-band, and with the boards extended, the hollow is pulled a little away from the back, and the leather is neatly tucked in. The leather is next tightly brought over the boards and well rubbed down, both on the edge and inside, with a folding stick, but on no account must the outside be rubbed, or the grain will be taken away. The fore-edge is treated in like manner, by tucking the corners in for strength. The head-band is set by tying a piece of thread round the book, between the back and the boards, in the slots cut out from the corners of the boards; this thread must be tied in a knot. The book being held in the left hand, resting on its end, the leather is drawn with a pointed folding-stick, as it were, towards the fore-edge, and flattened on the top of the head-band. When this is done properly, it should be exactly even with the boards, and yet cover the head-band, leaving that part of the head-band at right angles with the edge exposed. A little practice will indicate what amount of leather is to be left out from the turning in, so that the head-band can be neatly covered. The perfection in covering a book depends upon the leather being worked sharp round the boards, but with the grain almost untouched.

Paste should be always used for all kinds of leather; but leather with an artificial grain should be glued, the turning in being pasted. The glue gives more body to the leather, and thus preserves the grain. White morocco should be covered with paste made without alum, which turns it yellow. If the leather is washed with lemon-juice, instead of vinegar, when finishing, the colour will be much improved.

Russia leather is pared in the same way as morocco. It should be damped and rolled with a rolling-pin before covering.

Calf, either coloured or white, need be pared only round the head-band; it should be covered with paste, and the book washed, when covered, with a clean damp sponge. In putting 2 books together, when of calf of 2 different colours, a piece of paper should be placed between, as most colours stain each other, especially green. Care should be taken to finger calf as little as possible; whilst wet, touching it with iron tools, such as knives and band nippers, will cause a black stain. Morocco will bear much handling.

Vellum or Parchment.—The boards should be covered with white paper, to avoid any darkness of the board showing through. The vellum or parchment should be pared at head and tail, and the whole well pasted and allowed to stand for a short time, so that it be well soaked and soft. The book should then be covered, but the vellum must not on any account be stretched much, or when dry it will draw the boards up to a remarkable extent. If the book be pressed, the vellum will adhere better. Old binders took great pains in covering their white vellum books. The vellum was lined carefully with white paper and dried before covering: this in some degree hindered the shrinking in drying, and enabled the workman to give the boards a thin and even coat of glue, which was allowed to dry before putting on the covering.

Roan is covered with glue and turned in with paste. Head and tail only need be pared round the head-band.

Cloth is covered by glueing the cover all over and turning in at once; glueing one cover at a time, and finishing the covering of each book before touching the next.

Velvet should be covered with clean glue not too thick; first glue the back of the book and let that set before the sides are put down. The sides of the book should next be glued, and the velvet laid down, turned in with glue. The corners should be very carefully cut or they will not meet, or cover properly when dry. When the whole is dry, the pile may be raised, should it be finger marked, by holding the book over steam, and, if necessary, by using a brush carefully.

Silk and Satin should be lined first with a piece of thin paper cut to the size of the book, glued with thin clean glue, rubbed down well, and allowed to get dry, before covering the book. When dry, cover it as with velvet.

Half-bound Work.—The book has its back, a part of the sides, and the corners covered with leather. The sides are, after the leather is perfectly dry, covered either with cloth or paper according to fancy, turned over the boards as with leather. The book is then pasted down. Before the paper is put on the sides, all unevenness of the leather is pared away. This style has come very much into reputation lately on account of its economy; the amount of leather required is less, and the work is as strong and serviceable as in a whole-bound book. It will be better if the back be finished before the corners are put on, as there is great likelihood that the corners may get damaged to some extent during the process of finishing. The outside paper may either match the colour of the leather, or be the same as the edge or end-papers.

Pasting Down.—This is to cover up the inside board by pasting down the end-papers to the boards.

The white or waste leaf, that has till this process protected the end-papers, is now taken away or torn out. The joint of the board must be cleaned of any paste or glue that may have accumulated there, by passing the point of a sharp knife along it so that when the end is pasted down, the joint will be quite straight and perfectly square.

Morocco books should be filled in with a smooth board or thick paper, the exact substance of the leather. This thickness must be carefully chosen, and one edge be cut off straight, and stuck on the inside of the board very slightly, in fact only touching it in the centre with a little glue or paste, just sufficient to hold it temporarily. It must be flush with the back-edge of the board. When dry, the paper or board is marked with a compass about ½ in. round, and both paper and leather are cut through at the same cut with a sharp knife. The overplus board will fall off, and the outside of the leather may be easily detached by lifting it up with a knife. The paper or board, which will now fit in exactly, should be glued and well rubbed down with a folding-stick, or it may be put into the standing press if the grain of the morocco is to be polished, but not otherwise.

Joints.—Morocco books only have morocco joints, thus made. Morocco of the same colour is cut into strips the same length as the book, and about 1½ in. in breadth for 8vo; a line is drawn or marked down each strip about ½ in. from its edge, with a pencil or folder, as a guide. The leather is pared from the mark to a thin edge on the ½-in. side, and the other side is pared as thin as the leather turned in round the board, so that there will be 2 distinct thicknesses on each piece; the larger half going on the board to correspond with the leather round the 3 sides, and the smaller and thinly pared half going in the joint and edge on to the book. The end-papers, only held on with a little paste, are lifted out from the book, the leather, well pasted is put on the board, so that the place where the division is made in the leather by paring will come exactly to the edge of the board; the thin part should then be well rubbed down in the joint, and the small thin feather edge allowed to go on the book.

Great care must be taken to rub the whole down well, that it may adhere properly; the grain need not be heeded. With regard to the overplus at the head and tail, there are two ways of disposing of it; first by cutting both leathers slanting through at once, and making the two meet; or, secondly, by cutting the cover away in a slant and doing the same to the joint, so that the 2 slant cuts cover each other exactly. This requires very nice paring, or it will be seen in the finishing. The book should be left till quite dry, which will take some 5–6 hours. The boards are then filled in by the same method, and the end-papers are fastened in again properly

Cloth Joints.—If the cloth has been stuck in when the ends were made, after cleaning all unevenness from the joints, the boards are filled in as above, and the cloth joint is stuck down with thin glue, and rubbed down well. The marble paper may now be put on the board by cutting it to a size, a little larger than the filling in of the board, so that it may be well covered. When cloth joints are put in, the board paper is generally brought up almost close to the joint; but with morocco joints, the space left all round must be even.

Calf, Russia, etc.—After having cleaned the joint, the leather is marked all round a trifle larger than the size intended for the end-papers to cover. Then with a knife, the leather is cut through in a slanting direction by holding the knife slanting. The boards should be thrown back to protect the leather, and the book placed on a board of proper size, so that both book and board may be moved together, when turning round. When the leather is cut, a piece of paper should be pasted on the board to fill up the thickness of the leather, and to curve or swing the board back; the boards otherwise are sure to curve the contrary way, especially with calf. When this lining is dry, the end-papers may be pasted down.

There are 2 methods of doing this. In the most exact, the paper is pasted all over, especially in the joint, and the paper being held in the left hand, is well rubbed down, more particularly in the joint. The paper is marked all round (head, fore-edge, and tail) with a pair of compasses to the width required for finishing inside the board. With a very sharp knife, the paper is to be cut through to the depth of the paper only, by laying the straight-edge on the marks made by the compasses. This has the advantage of procuring an exact margin round the board; but it must be done quickly, or the paper will stick to the leather round the board from the paste getting dry, the leather absorbing the watery particles in the paste. The other way is to lay the paper back, and down on the board, and then to mark it. A tin is then placed between the book and paper, and the paper is cut to the marks made. The paper is then pasted down as above. When pasted down, the book should be left standing on its end, with boards left open until thoroughly dry, which will be about 6 hours. A tin should be kept especially for cutting on, and the knife must be as sharp as possible. This latter method is used for all half bindings.

Hand-finishing.—Hand-finishing is really an art. The finisher should be able to draw, or at least have some knowledge of composition, and also know something about the harmony of colours. Taste has no small influence. It is better to finish books plainly, rather than put on more gold than is necessary. Let the tools be always in keeping with the book, both in size and character. Large ones should be used only on a large book, and those of less size for smaller works. A book on Natural History should have a bird, insect, shell or other tool indicative of the contents. A flower should be used on works on Botany, and all other works should be treated in the same emblematical manner. In lettering, see that the letters are of a size proportionate to the book—legible but not too bold. They should neither be so large as to prevent the whole of the title being read at one view, nor so small as to present a difficulty in ascertaining the subject of a book when on the shelf. Amongst a large number of books, there should be an agreeable variety of styles, so that the effect may be in harmony with the colours around, and produce as pleasing a contrast as possible.

Tools and Materials.—These embrace rolls, fillets, pallets, centre and corner tools of every possible class and character; type of various sizes for lettering books or labels. The type may be either of brass or printers' metal; if the latter, care must be taken that it be not left at the fire too long, or it will melt. Type-holders are made to fit the respective sizes, but one or two with a spring side, adjusted by screw, will be found convenient for any type. In England it is the custom to letter books with hand letters, each letter being separate and fixed in a handle. Doubtless these will in time be laid aside, and the type and type-case will be adopted.

Of polishing-irons 2 are necessary—one for the sides and one for the backs. Often a third is kept for polishing the board end-papers when pasted down.

The gold-rag, to wipe off the surplus gold from the back or side of a book, should have a little oil well worked into it, so that the gold may adhere to and remain in it. This rag when full of gold will be of a dirty yellow, and may then be melted down by a gold-refiner, and the waste gold recovered.

Rubber, cut up very small—the smaller the better—and steeped in turpentine so as to make it as soft as possible, is used for clearing away any gold not taken off by the gold-rag. This should also be melted down when full.

Sponges are wanted—large ones for paste-washing, smaller for glairing and sizing.

Glaire may be purchased already prepared, or it may be made from white of egg very carefully beaten up to a froth with a whisk. In breaking the egg, care must be taken not to let any of the yolk get amongst the white. A little vinegar should be mixed with the white before beating up, and a drop of ammonia, or a grain or two of common table salt, or a small piece of camphor, will in some measure prevent it from turning putrid, as it is liable to do. Some workmen keep a stock of "good old glaire," as they term it, by them, fancying that it produces better work; but this is a mistaken notion. When well beaten, allow the glaire to stand for some hours, and then pour the clear liquid into a bottle for use.

Cotton wool is used for taking the gold leaf up and pressing it firmly on the leather.

Varnish should be used only on that part where glaire has been applied and has afterwards been polished, the object being to restore brilliancy and preserve the leather from the ravages of insects attracted by the glaire. These pests do great damage to the covers of books prepared with glaire, taking away the surface of the leather and spoiling the appearence. Varnish may be purchased at all prices; use only the best, and be very sparing with it,

A small pair of spring dividers, some lard, sweet oil, and a finishing stove, are also required. Before gas was introduced, use was made of the now almost extinct charcoal fire. A bookbinders' gas stove can now be purchased at prices varying with the size, which can be used to warm glue, make paste, and heat tools for finishing, besides a hundred other purposes. Where cost is an object, or where gas is not obtainable, charcoal may still be used. Any old tin may be utilised: make a number of large holes through the sides; fill it with some live charcoal, and place a perforated tin plate on the top. It will keep alight for hours, and impart quite enough heat for any purpose required. This primitive stove, however, must be placed on a stand or on a piece of thick iron, lest it become dangerous.

Styles.—Finishing is divided into 2 classes—"blind," "antique," or as it is sometimes called, "monastic"; and "gold-finished."

The term antique is mostly known in the trade; and when morocco antique or calf antique is mentioned, it means that the whole of the finishing is to be done in blind tooling. Not only this, but that the boards should be very thick and bevelled, and the edges either dull gilt or red, or gilt over red. This class of work is used extensively for religious books. A gold line introduced and intermixed with blind work gives a great relief to any class of antique work.

It is not necessary that a special set of tools be kept for antique work, although some would look quite out of keeping if worked in gold. As a general rule, antique tools are bold and solid, such as Venetian tools, whilst those for gold work are cut finer and are well shaded. The greater number work equally well in gold and in blind; but when a special style has to be followed, the various tools and their adaptation to that style must be studied.

The general colour of blind work is dark brown, and the proper way of working these antique tools is to take them warm and work them on the damp leather a number of times, thus singeing the surface only, until it has assumed its proper degree of colour. Antique work as a decoration, requires quite as much dexterity and care as gold work. Every line must be straight, the tools worked properly on the leather, both in colour and depth; and as the tools have to be worked many times on the same spot, it requires a very steady hand and great care not to double them. Some consider blind work as preparatory to gold work, and that it gives experience in the method of handling and working the various tools; and the degree of heat required for different leathers without burning them through. The leathers on which this work is mostly executed are morocco and calf.

In finishing the back of a book, it must always be held tightly in a small hand press, termed a "finishing press." This is of the same kind as a laying press, only much smaller, and is screwed up by hand. When in the press, mark the head and tail as a guide for the pallets by running a folding-stick along the edge of a piece of parchment or pasteboard held by the fingers and thumb of the left hand against the sides of the volume across the back at the proper place. When several books of the same character and size are to range together, the backs are compassed up so that the head and tail lines may run continuous when finished. In using the pallet, hold it firmly in the right hand, and let the working motion proceed from the wrist only, as if it were a pivot. It will be found rather difficult at first to work the pallets straight over the back and even to the sides of the bands, but after a little practice it will become easy to accomplish.

Morocco flexible work, as a rule, has blind lines, a broad and a narrow one, worked close to the bands. Damp the back with a sponge and clean water, and work it evenly into the leather with a hard clean brush. Take a pallet of the size suitable to the book, warm it over the stove, and work it firmly over the back. As the leather dries, make the pallet hotter; this will generally be found sufficient to produce the required dark lines. Sometimes it will be necessary to damp the different places 2 or 3 times in order to get the proper colour in the blind tooling.

The pallets will have a tendency to stick to the leather and possibly burn it. To obviate this, take 1½ oz. white wax, and 1 oz. deer fat or lard, place them in a pipkin over a fire or in a warm place, so that they may be well mixed together; when mixed, allow to cool. Rub some of this mixture upon the rough or fleshy side of a piece of waste morocco, and when working any tools in blind, rub them occasionally over the prepared surface. This mixture will be found of great service in getting the tools to slip or come away from the leather in working. Lard alone is sometimes used, but this mixture will be found of greater service to any finisher, and the advantage of adding the wax will be apparent,

The lines impressed on the back must now have their gloss given to them. This is done by "giggering" the pallets over them. Make the pallet rather hot, rub it over the greased piece of leather, and work it backwards and forwards in the impression previously made. Great care must be taken that the pallet be kept steadily in the impressions already made, or they will be doubled. The back is now ready for lettering, as described farther on.

To blind tool the side of a book it must be marked with a folder and straight-edge, according to the pattern to be produced; and as a guide for the rolls and fillets to be used. These lines form the ground plan for any design that has to be worked. Damp the whole of the side with a sponge, and brush it as before directed; then work the fillets along the lines marked. Run them over the same line 2 or 3 times. When dry, make the fillet immovable by driving a wooden wedge between the roll and fork, and gigger it backwards and forwards to produce the gloss. If tools are to be worked, make them slightly warm, and, as the leather dries, make the tool hotter and hotter. This must be repeated as often as necessary until the desired depth of colour and gloss is obtained. In using a roll that has a running or continuous pattern, a mark should be made upon the side with a file, at the exact point that first comes in contact with the leather, so that the same design may always come in the same place in the repeated workings. It is impossible for a roll to be cut so exactly that it may be worked from any point in the circumference without doubling it. Blind work is done in the same way whether in using a small tool or a large roll. The leather must be damped and repeatedly worked until the depth of colour is obtained. It is then allowed to dry, and reworked to produce the gloss. The beauty of blind work consists in making the whole of the finishing of one uniform colour, and in avoiding the fault of having any portion of the work of lighter tint than the rest.

Gold Work.—This is far more complicated than blind or antique work, so that it is better to practise upon some spare pieces of roan, calf, and morocco, before attempting to finish a book. Gold work is not more difficult than blind tooling, it is only more complicated. The different kinds of leather require such different degrees of heat, that what would fail to make the gold adhere upon one leather, would burn through another. The various colours require different degrees of heat; as a rule, light fancy colours need less than dark.

The medium by which the gold is made to adhere to the leather is used in 2 ways—wet and dry. The wet is used for leather, the dry for velvet, satin, silk and paper.

The wet medium is again divided into 2 classes, one for non-porous and another for porous leather. Morocco is the principal of the non-porous leathers, with roan and all other imitation morocco. The porous varieties consist of calf of all kinds, russia and sheep.

The non-porous leathers need only be washed with thin paste water or vinegar and glaired once; but if the glaire be thin or weak it will be necessary to give them a second coat of glaire.

The porous varieties must be paste-washed carefully, sized all over very evenly, and glaired once or twice; care being taken that the size and glaire be laid on as evenly as possible.

All this, although apparently so simple, must be well kept in mind, because the great difficulty is in not knowing the proper medium for the various leathers, and one book may be prepared too much, while another may have a deficiency. As a consequence one book will be spoiled by the preparation cracking, and the gold will not adhere to the other. By following the directions here given the gold will adhere without much trouble, beyond the practice necessary in becoming accustomed to an accurate use of the various tools.

Suppose that a half-morocco book is to be neatly finished and lettered. Take a broad and narrow pallet of a suitable and proper size, work it against the bands in blind as a guide for finishing in gold. As the impression need be but very slight, warm the pallet on the gas stove but very little. Choose some suitable tool, as a centrepiece to go between the bands. Work this also lightly on the back exactly in the centre of each panel as truly as possible and perfectly straight. A line made previously with a folding-stick along the centre of the back will greatly assist in the working of a tool in its proper position. Wash the back with vinegar, and brush it well with a hard brush to disperse the moisture and drive it equally into the leather; some use paste-water for this purpose instead of vinegar. Paste-water has a tendency to turn grey in the course of time: this is avoided by using vinegar, which also imparts freshness to the morocco, and keeps it moist a longer time, very desirable in finishing.

The impressions made by the broad and narrow pallet and the centre tool are pencilled in with glaire; when dry, pencil in another coat; allow this again to dry, then rub them very slightly with a piece of oiled cotton wool. Take a leaf of gold from the book and spread it out evenly on the gold cushion; cut it as nearly to the various shapes and sizes of the tools as possible. Take one of the pieces of gold upon a large pad of cotton wool, greased slightly by drawing it over the head. (There is always a sufficient amount of natural grease in the hair to cause the gold to adhere to cotton drawn over it.) Lay the gold gently but firmly on the impressed leather. See that the whole of the impression be covered, and that the gold be not broken. Should it be necessary to put on another piece of gold leaf, gently breathing on the first will make the second adhere.

When all the impressions are covered with gold leaf, take one of the tools heated to such a degree that when a drop of water is applied it does not hiss, but dries instantly; work it exactly in the blind impressions. Repeat this to the whole of the impressions, and wipe the overplus of gold off with the gold-rag. The impressions are now supposed to be worked properly in gold but if there are any parts where the gold does not adhere, they must be re-glaired and worked in again. A saucer should be placed near at hand with a piece of rag or a sponge and water in it, to reduce any tool to its proper heat before using. If the tool be used too hot, the gold impression will be dull—if too cold, the gold will not adhere. To use all tools of the exact degree of heat required is one of the experiences of the skilled workman.

The back is now ready for the title. Set up the words in a type-case, with type sufficiently large and suitable to the book. The chief word of the title should be in somewhat larger size than the rest, the other diminishing, so that a pleasant arrangement of form be attained. In order to adjust the length of the words, it may be necessary to "space" some of them—that is to put between each letter a small piece of metal called a "space." Square the type, or make the face of the letters perfectly level by pressing the face of them against a flat surface before tightening the screw. They must be exactly level one with another, or in the working some of them will be invisible. Screw the type-case up, warm it over the finishing stove, and work the letters carefully in blind as a guide. Damp the whole of the lettering space with vinegar. When dry pencil the impressions in twice with glaire. Lay the gold on and work them in gold.

But with lead type and a spring type-case (more suitable for amateurs on account of its relative cheapness, and the case fitting itself to the different sizes of the type) the latter must be warmed before the type is put in. The heat of the case will impart sufficient heat for the type to be worked properly. If the case and type be put on the stove, the type will probably be melted if not watched very narrowly. Hand letters are letters fixed in handles and each used as a single tool. The letters are arranged in alphabetical order round the finishing stove, and as each letter is wanted it is taken from the order, worked, and replaced. They are still very much used in England, but where several books are to have the same lettering, brass type is very much better. It does its work more uniformly than hand letters, however skilfully used.

When this simple finishing can be executed properly and with ease, a more difficult style may be attempted, such as a "full gilt back." This is done in 2 ways, a "run up" back and a "mitred" back. As a general rule, morocco is mitred. Place the book on its side, lift up the millboard and make a mark at head and tail on the back, a little away from the hinge of the back. Then with a folder and straight-edge mark the whole length of the back: this is to be done on both sides. Make another line the whole length down the exact centre of the back. With a pair of dividers, take the measurement of the spaces between the bands, and mark the size at head and tail for the panels from the top and bottom band; with a folder and strip of parchment make a line across the back, head and tail, at the mark made by the dividers.

Work a thin broad and narrow pallet alongside the bands in blind. Prepare the whole of the back with vinegar and glaire, but lay the glaire on with a sponge. When dry, lay the gold on, covering the whole of the back with it, and mending any breaks. For mitreing, take a 2-line pallet that has the ends cut at an angle of 45°, so that the join at that angle may be perfect. Work this on the side at the mark made up the back, and up to the line made in blind across the back. Repeat this to each panel. The 2-line pallet must be worked across the back and up to the lines made in gold, the cutting of the pallet at the angle will allow of the union or mitre, so that each panel is independent of the other. There will be spaces left at head and tail, which may be filled up with any fancy pallet or repetition of tools. The corners should be in keeping with the centre, and large enough to fit the panel. Work these from the sides of the square made, or from the centre of the panel, as will be found most convenient according to the thickness of the book and style of finishing, and then fill in any small stops. When the whole is done, rub the gold off with the gold rag, and use the rubber if necessary. The title is put on in the manner before described.

It is not always necessary that the finishing be done in blind first. One accustomed to finishing finds that a few lines marked previously with a folding-stick are all that is required. When working the title, a thread of silk drawn tightly across the gold produces a sufficient line, and is the only guide that an experienced workman requires.

To finish a side, make a mark with the folder and straight-edge as a guide for rolls or fillets. Prepare the leather, as before described, where the ornamentation is to come; but if the pattern is elaborate, it must be worked first in blind. As a greater facility, take a piece of paper of good quality and well sized. Draw the pattern on the paper, and if any tools are to be used, hold them over the gas flame; this will smoke them so that they may be worked on the paper in black. When the pattern is complete in every detail, tip the 4 corners of the paper with a little paste, then work the pattern through the paper on to the leather, using the various sized gouges as the scrolls require, and a single line fillet where there are lines. Work thus the complete pattern in blind. This being done completely, take the paper off from the 4 corners, place it on the other side, and work it in the same way. Prepare the leather with vinegar, and pencil the pattern out with glaire. If the whole side be glaired with a sponge, it will leave a glossy appearance that is very undesirable. The whole side is now laid on with gold, and the pattern is worked again with the warm tools, in the previous or blind impressions.

The inside of a book is generally finished before the outside. This should be done as neatly as possible, carefully mitreing the corners when any lines are used. Most frequently a roll is employed, thus saving a great deal of time. A style was introduced in France called "doublé," the inside of the board being covered with a coloured morocco different from the outside, instead of having board papers. This inside leather was very elaborately finished; generally with a "dentelle" border, while the outside had only a line or two in blind. It is a style which, although very good in itself, has quite died out with us, so many prefer to see the finishing to having it covered up when the book is shut.

The edges of the boards and the head-bands must be finished either in gold or blind, according to fancy, and in keeping with the rest of the embellishment. A fine line worked on the centre of the edge of the board by means of a fillet looks better, and of course requires more pains than simply running a roller over it. If it is to be in gold, simply glairing the edge is sufficient. Lay on the gold, and work the fillet carefully. Place the book on its ends in the finishing press to keep it steady, or it will shake and throw the fillet off. If a roll is used, take the gold up on the roll, grease it first a little, by rubbing the gold-rag over the edge to make the gold adhere. Then run the roll along the edge of the boards; the kind generally used for this purpose is called a "bar roll"—that is, having a series of lines running at right angles to the edge of the roll.

Imitation morocco is generally used for publishers' bindings, where books are in a large number and small in price; and the finishing is all done with the blocking press. To finish this leather by hand, it is advisable to wash it with paste-water and glaire twice.

Roan is generally used for circulating library work, and is very seldom finished with more than a few lines across the back and the title. This leather is prepared with paste-wash and glaire, and, when complete, varnished over the whole surface.

Inlaid Work.—Inlaid, or mosaic work, is used only in the higher branches of bookbinding. Formerly books were not inlaid, but painted with various colours. Grolier used a great deal of black, white and green. Tuckett employed a method of extracting one colour from leather and substituting another by chemical action, thus: Take dark chocolate colour, trace the design thereon, and pick it out or pencil it in with suitable chemicals, say dilute nitric acid; this will change the chocolate, leaving the design a bright red on a chocolate ground.

To lay on the various colours with leather is, no doubt, by far the better plan. Paint has a tendency in time to crack, and, if acids are used, they will to a certain extent rot or destroy the leather; but if leather is used it will always retain both colour and texture. To choose the proper colours that will harmonise with the ground, give tone, and produce the proper effect, requires a certain amount of study. Morocco is generally used, but in Vienna calf has given very good results. If the pattern to be inlaid be very small, steel punches are used, the pattern being worked in blind on the side of the book. Take morocco of a different colour from the ground it is to decorate, pare it down as thin as possible, and lay it on a slab of lead. With a steel punch, the exact facsimile of the pattern that is to be inlaid, punch out from the leather the required number of pieces. These are pasted and laid very carefully on the exact spot made by the blind tooling; press each down well into the leather either with a folding-stick or the fingers, so that it adheres properly. When dry, the book is pressed between polished plates, so that the raised pieces, or the pieces that have been laid on, may be forced well into the ground leather. When it has been pressed, the whole of the leather must be prepared as for morocco, and finished in gold. The tools in the working will hide all the edges of the various inlaid pieces, provided they are laid on exactly.

If interlacing bands are to be of various colours, the bands must be cut out. Pare the leather thin, and after working the pattern through the paper on to the leather on the side of the book, lay it on the thinly pared leather; with a very sharp and pointed knife, cut through the paper and leather together on a soft board. Or, the design may be worked or drawn on a thin board, and the various bands cut out of the board as patterns. Lay these on the thin leather and cut round them. Keep the board templates for any future use of the same patterns. The various pieces are pasted, carefully adjusted in their places, and well rubbed down. The leather is then prepared and worked off in gold.

Another method is to work the pattern in blind on the sides, pare the morocco thin, and while damp place it upon the portion of the pattern to be inlaid, and press it well with the fingers, so that the design is impressed into it. Lay the leather carefully on some soft board, and cut round the lines made visible by the pressure with a very sharp knife. When cut out, paste and lay them on the book and prepare as before, and finish in gold. This last method is not of much value, though it is sometimes chosen; for any good work, where accuracy is required, the plans mentioned previously are to be preferred.

The Viennese work their calf in the same way that the cabinet-makers inlay woodwork. With a very sharp and thin knife, they cut right through two leathers laid one on the other. The bottom one is then lifted out and replaced by the top one. By this method the one fits exactly into the other, so that, if properly done, the junctions are so neatly made that no finishing is required to cover the line where the two colours meet.

Porous.—Calf, as before described, requires more and different preparation than morocco, on account of its soft and absorbing nature. As a foundation or ground-work, paste of different degrees of strength is used, according to the work required.

Calf books have generally a morocco lettering piece of a different colour from the calf on the back for the title. This is, however, optional. Leather lettering pieces have a great tendency to peel off, especially if the book be exposed to a hot atmosphere, or if the paste has been badly made, so that it is perhaps better if the calf itself be lettered. There is no doubt that a better effect is produced in a bookcase when a good assortment of coloured lettering pieces is placed on the variously coloured backs, and the titles can be more easily read than if they were upon light or sprinkled calf; but where wear and tear have to be studied, as in public libraries, a volume should not have any lettering pieces. All such books should be lettered on their natural ground.

For lettering pieces, take morocco of any colour, according to fancy, and having wetted it to facilitate the work, pare it down thin and evenly. Cut it to size of the space it is intended to fit, pare the edges all round, paste it, put it on the place, and rub well down. Should the book require two pieces—or one for the title, and one for the volume or contents—it is better to vary the colours. Do not allow the leather to come over on to the joint, or by the frequent opening of the boards the edge will become loose. A very good plan as a substitute for lettering pieces is to colour the calf dark brown or black, thus saving the leather at the expense of a little more time. When the lettering pieces are dry, mark the back, head and tail for the pallets or other tools with a folding-stick. Brush paste all over the back. With the handle of an old tooth-brush, rub the paste into the back. Before it has time to dry, take the overplus off with a rather hard sponge, dipped in thin paste-water. The reason why paste of full strength must be used for the back, and only paste-water for the sides, is, that through the stretching of the leather over the back in covering, the pores are more open, and consequently require more filling up to make a firm ground. Much depends upon the ground-work being properly applied.

Finishing, above all other departments, demands perfect cleanliness. A book may have the most graceful designs, the tools be worked perfectly and clearly, but be spoiled by having a dirty appearance. See that everything is clean—paste-water, size, glaire, sponges, and brushes. Do not lay any gold on until the preparation is perfectly dry, or the gold will adhere and cause a dirty yellow stain where wiped off.

Should the calf book be intended to have only a pallet alongside the bands, it is only necessary where the paste-wash is quite dry to glaire that portion which is to be gilt: this is usually done with a camel-hair brush, by laying on 2 coats. When dry, cut the gold into strips and take one up on the pallet and work it on the calf. This is what is termed "half calf neat." The band on each side is gilt, leaving the rest of the leather in its natural state. Some binders polish their backs instead of leaving them dead or dull.

Full gilt back.—(*a*) "*Run-up.*" Make a mark up the back on both sides a little away from the joint with a folder and straight-edge. Put on lettering piece. When dry, paste and paste-wash the back. When again dry, take some of Young's patent size, melt it in a pipkin with a little water and apply it with a sponge. Lay this on very evenly with a very soft sponge, and be particular that it is perfectly clean, so that no stains be left. When this size is done with, put it on one side for future use. This size should not be taken of its full strength, and when warmed again some more water should be added to make up for evaporation. When the coat of size has dried apply 2 coats of glaire. The first must be dry before the second is applied, and great care should be taken that the sponge does not go over the same place twice, or the previous preparations will be disturbed. It is now ready for finishing. Cut the gold to proper size; rub a little lard over the whole of the back with cotton wool. This requires great attention. Very little must be put on light or green calf, as these colours are stained very readily. Take the gold up on a cotton pad; lay it carefully down on the back; breathe on the gold, and press down again. If there be any places where the gold is broken, they must be mended. Heat a 2-line fillet so that it hisses when placed in the cooling pan or the saucer with the wet rag in it, and run it the whole length of the back on the line made before paste-washing. Do this on both sides, and rub the gold off with the gold-rag up to the line on the outside. Work a 2-line pallet on each side of the bands, and tho morocco lettering piece last as it requires less heat. The centre piece of each panel is next worked, firmly but quickly. The corners are worked from the centre or sides using the right hand corners as a guide, and judging the distance by the left hand ones. The press must be turned when it is required to bring the left side to the right hand in working the corners. The requisite pallets are worked to finish the book head and tail, generally in one operation with the 2-lined pallet.

Calf-work requires very quick working. The tools must not be held over the various places too long, or the heat will destroy the adherent properties of the albumen. With morocco this does not signify so much, as the heat is not so great.

(*b*) "*Mitred back*" is prepared tho same way as for "run up back," and the mitreing is done as explained in working morocco. This is superior work, requires more skill, and takes longer, but looks much better. Each panel must be an exact facsimile of the rest. If the tools do not occupy precisely similar places in each panel, the result will be very unsatisfactory. When the backs are finished rub the gold off with the gold-rag, and clear off any residue with rubber. Be very careful that every particle of the surplus gold be cleared off or the delicate lines of the ornaments will be obscure and ragged in appearance.

The book is now ready for lettering. Set the type up in the case, and work it carefully in a perfectly straight line over the back. The whole of the back is polished with the iron, which must be perfectly clean and bright. Prepare a board from an old calf binding, by applying some fine emery or charcoal and lard on the leather side of it. Rubbing the iron over this prepared surface will give it a bright polish. It must be used over the back by holding it lightly and giving it an oblong circular motion. Go over every portion of the back with very even pressure, so that no part may be made more glossy than another. The polishing iron should be used rather warmer than the tools: but if too hot, the glaire will turn white; if too cold, the polish will be dull.

The grease upon the leather will be quite sufficient to make the polisher glide easily over the surface, but the operation must be rapidly and evenly done. All light and green calf requires less heat than any other kinds, and will turn black if the iron be in the least degree too hot.

The sides should be always in keeping with the back. Before the sides can be finished, the inside of the boards must receive attention. With a "run up" back, the edge of the leather round the end-papers is worked in blind or has a roll run round it in gold. In any case it should be paste-washed. If for blind, the roll is heated and worked round it; if for gold, it is glaired twice. The gold, cut into strips, is taken up on the roll, worked, and the overplus taken off with the rag as before directed. Extra work, such as mitred, should have some lines or other neat design put on. Paste-wash the leather, and, when dry, glaire twice. When again dry, lay on the gold all round, and work the single or other fillets, or such other tool as may be in keeping with the exterior work. When the gold has been wiped off, the leather is polished with the iron.

The outside must now be finished. If the sides are not to be polished, paste-wash the whole of the side up to the edge of the back carefully, then glaire only that portion which is to be gilt. In general a 2-line fillet only is used round the edge, so that the width of the fillet or roll must determine the width to be glaired. When glaired twice and dry, take up the gold on the fillet or roll and work it evenly and straightly round the edge. The corners where the lines meet are next stopped by working a small rosette or star on them. Clean off any gold that may be on the side, and work a small dotted or pin-head roll at the edge of the glaire. This will cover and conceal the edge.

Extra calf books generally have the sides polished. Paste-wash the sides all over, and size when dry. Hold the book, if small, in the left hand; if large, lay it on the press and work the sponge over the side in a circular direction, so that the size may be laid on evenly. Be very careful that it does not froth; should it do so squeeze the sponge out dry, and fill it anew with fresh size. Some workmen work the sponge up and down the book, but if this be not done very evenly it produces streaks. Allow to dry by leaving the book with boards extended. When perfectly dry, glaire once. This will be found sufficient, as the size gives body to the glaire. When sizing and glairing, be sure that the book is laid down with the boards extended on a level surface; if the book be not level, the size or glaire will run down to the lowest portion of the surface and become unequally distributed.

The gold is now laid on the respective places, either broad or narrow, according to the nature of the finishing or width of the rolls. As a rule, the sides of the better class of calf books are only 3-lined round the edge and mitred in the corners. This is, however, quite a matter of taste. Some have a border of fancy rolls, but never any elaborate pattern as in morocco work. To finish the sides, place the book in the finishing press with the boards extended, so that they may rest on the press. This will afford greater facility for working the fillets, rolls, and tools necessary to complete the design on each side. The finishing press being small, it can be easily turned round as each edge of the border is finished.

To polish the sides, place the book on its side on some soft surface, such as a board covered with baize, and kept for the purpose. Use the large and heavy polishing iron, hot and clean. Work the iron quickly and firmly over the sides, first from the groove towards the fore-edge, and then in a contrary direction from the tail to the head by turning the volume, The oil or grease applied to the cover previous to laying on the gold will be sufficient to allow the polisher to glide easily over the surface. Polishing has the effect of smoothing down the burr formed on the leather by the gilding tools, and bringing the impressions up to the surface. The iron must be held very evenly, so that its centre may be the working portion. If held sideways, the edge of the iron will indent the leather. The heat must be sufficient to give a polish; but if the iron is too hot, it will cause the glaire to turn white. A practised finisher can generally tell the proper heat on holding the iron at some little distance from his face. Calf books should be pressed, whether polished or not.

Pressing.—Plates of japanned tin or polished horn are proper for this purpose. Put pressing tins between the book and the millboards, up to the joint. Place one of the japanned tins on the side level with the groove, turn the book and japanned tin over carefully together, so that neither shifts; lay another of the japanned tins on the top of the book, thus leaving the book between 2 tins. Put the book into the standing press, screw down tightly, and leave for some hours. When pressed sufficiently, take the book out, and if the sides are polished, varnish them.

Make a little pad of cotton wool, saturate the lower portion with varnish; rub it on a piece of waste paper to equalise the varnish, then work the pad over the side as quickly as possible, in a circular direction. Renew the wool with varnish for the other side. Enough must be taken on the pad to varnish the whole side, as the delay of renewing the varnish would cause a streaked surface. When the varnish is perfectly dry, the book is again pressed. To do this, rub the gold rag over the sides to give them a little grease, which will prevent the sides from sticking to the polished plates. Place the book between the plates as before, leaving out the pressing tins, and put into the standing press. Only little pressure must be given; if the press is screwed down too tightly, the plates will stick to the book. The varnish must be of good quality, and perfectly dry. Half an hour in the press will be found quite long enough. Should the plates stick, there is no other remedy than washing off the varnish with spirits of wine, and the glaire and size with warm water; then carefully repreparing the whole surface as before. This is, however, an accident which cannot happen if due care and judgment be exercised.

Graining.—Graining is now used very much on calf books. This may be properly considered as a blind ornament. It is done by means of copper or wooden plates cut out in various patterns so as to form small squares, scales of fish, or an imitation of morocco. Place the volume between 2 of these plates even up to the groove of the back, in the standing press; screw it tightly down. The impressions should be equal over the whole surface. Nothing looks worse than a bold impression in one place and a slight one in another, so that it is important that it be evenly pressed; a second application of the plates is impracticable. Graining has the advantage of hiding any finger marks that may accidentally be on the calf, and conceals any imperfections in the leather.

The state of the weather must in a great measure guide the finisher as to the number of volumes to prepare at one time. The leather should always be a little moist, or rather "fresh." In winter, double the number of books may be prepared, and the gold laid on, than the dryness of a summer's day will admit of. If books are laid on overnight, the tools must be used very hot in working them the next morning, or the gold will not adhere. During summer, flies will eat the glaire from various places while the book is lying or standing out to dry, so that constant vigilance must be kept to avoid these pests.

Russia leather is prepared in the same way as calf, but is usually worked with more blind tools than with gold, and the sides are not as a rule polished, so that the size and glaire are dispensed with, except on those parts where it is to be finished in gold; and those portions need be only paste-washed and glaired once without any size.

Finishing with Dry Preparation.—Dry preparation is used for silk, velvet, paper, or any other material that would be stained by the employment of the wet process. A number of recipes are in use.

(*a*) Dry some white of egg by spreading it somewhat thickly over glass plates, preserving it from dust. It will chip off readily, when dry, if the glass has been previously very slightly oiled or greased. It must not be exposed to a greater heat than 122° F. (50° C.), or the quality of the albumen will be destroyed. The dried mass is well powdered in a porcelain mortar.

(*b*) Take equal portions of mastic, sandrac, and arabic gums, and grind them in a mortar into an impalpable powder.

Put it into a box or bottle, and tie 3 or 4 thicknesses of fine muslin over the mouth. By tapping the inverted box, or shaking it over the lines or letters, the dust will fall through in a fine shower. The powder should fall only on the part to be gilt. Cut the gold into strips, take it upon the tool, and work it rather hot. The overplus of the powder must be brushed away when the finishing is completed.

Velvet is very seldom finished beyond having the title put on, and this should be worked in blind first and with moderately large letters, or the pile will hide them.

Silk is finished more easily, and can, if care be taken, have rather elaborate work put upon it. In such a case, the lines or tools, which must be blinded-in first, may be glaired. For this purpose, the glaire is put in a saucer or plate in the free air for a day or two, so that a certain amount of moisture may evaporate; but it must not be so stiff as to prevent the brush going freely over the stuff. Great care must be taken, or the glaire will spread and cause a stain. A thin coat of paste-water will give silk a body and keep the glaire from spreading to a certain extent; but the best medium for silk is the dry one, as it is always ready for instant use. In using glaire, the gold is laid on the silk, but on no account must any oil or lard be rubbed on it for the temporary holding of the gold. Rub the parts intended for the gold with the finger (passed through the hair) or with a clean rag lightly oiled, and when the tools are re-impressed, use a clean piece of flannel to wipe off the superfluous gold.

Blocking has been used lately on silk with some success in Germany. The blocking plate is taken out of the press, and the gold is laid on it, and then replaced in the press. The finishing powder is freely distributed over the silk side, which is laid on the bed of the press. On pulling the lever over, the block descends and imprints the design in gold on the silk. This process may be applied to velvet, but velvet never takes the sharpness of the design on account of the pile, so that as a rule it is left in its natural state.

Vellum.—Several kinds of vellum are prepared from calf skins: "prepared" or "artists'" vellum, with a very white artificial surface; "Oxford" vellum, the surface of which is left in its natural state; "Roman" vellum, which has a darker appearance. Parchment is an inferior animal membrane prepared from sheep-skins after the manner of vellum, and is very successfully imitated by vegetable parchment, made by immersing unsized paper for a few seconds in a bath of dilute oil of vitriol. This is used very extensively in France for wrappering the better class of literature, instead of issuing them in cloth as is the custom here.

The method of finishing vellum is altogether different from leather. On account of its very hard and compact nature, it requires no other ground or preparation than glaire for gold work.

The cover should be washed with a soft sponge and clean water, to clean off any dirt or finger marks, and to make the book look as fresh as possible. This washing must be very carefully done by going over the surface as few times as possible. This caution applies particularly to the "prepared" vellum, as each washing will take off a certain amount of the surface. It requires some experience to distinguish the flesh and leather surfaces of prepared vellum, but this experience must be acquired, because it is absolutely necessary that the leather side should be outward when the book is covered, for two reasons: the flesh side is more fibrous and adheres better to the boards than the leather side, and the leather side is less liable to have its surface disturbed in the process of washing.

When dry, the parts that are to be gilt must be glaired, and as the glaire will show its presence, or more strictly speaking leave rather a dirty mark, the tools should be worked in blind, and the glaire laid on carefully up to their outer edge. When dry, lay the gold on and work the tool in. Let the tools be only moderately warm; if too hot, they will go through to the millboard, leaving their mark as if they had been cut out with a knife.

As a rule, no very heavy tooling is put on vellum, as the beauty lies in keeping the vellum clean. As the tooling, comparatively speaking, is on the surface, owing to the thinness of the skin, it requires a very competent and clean workman to produce anything like good work on vellum.

Vellum is of so greasy a nature that, if a title-piece of leather has to be put on, it will be a matter of great difficulty to make it adhere properly, unless some special precaution be taken. The best plan is to scrape the surface, where the leather is intended to be placed, with the edge of a knife. This will produce a rough and fibrous ground on which to place the pasted leather. This leather, when dry, must be prepared with paste-water and glaire, in the same manner as with other books.

Blocking.—The tools required for blocking are "blocks" or "stamps," composed of very small pieces, or in one block cut to the size of the book. In any case, the block has to be fastened to the movable plate at the bottom of the heating box of the blocking press. To block the sides of a book, glue a stout piece of paper upon the movable plate. Then set the blocks upon one side of the book in exact position, and place that side upon the bed of the blocking press, leaving the volume hanging down in front of the press. The bed is next fixed, so that the centre of the board is exactly under and in the centre of the heating box. When quite true, the sides and back gauges are fixed by screws. Pull the lever so that a slight pressure upon the plate be given; release the press and take out the book and examine if all be correct. Some of the blocks may require a small piece of paper as a pad, so as to increase the pressure, others to be shifted a little. Now glue the back of the stamps and replace them. Put the whole under the top plate in the press, heat the box, and pull the lever over; let the book remain for some little time to set the glue. Take out the book, examine if perfectly square and correct, but replace it with a soft millboard under the stamps and pull down the press. The lever must remain over and the blocks be under pressure until the glue is hardened.

Another method is to glue upon the plate a piece of thick paper, and mark upon it the exact size of the book to be blocked. Strike the size from the centre, and from that draw any other lines that may assist in placing the blocks. Arrange the blocks upon the plate so as to form the design; when correct glue the blocks on their backs, and replace them on the plate. When the glue adheres a little, turn the plate over and put it into the press. Apply heat to the box; pull the lever over; and when the glue is set, regulate the bed and gauges.

When the press is properly heated, throw back the lever: take out the millboard from under the stamp, and regulate the degree of pressure required by the side screw under the bed. Place upon the bed the side to be stamped, hold it firmly against the guides with the left hand, and with the right draw the lever quickly to the front. This straightens the toggles and forces down the heating box, causing a sharp impression of the stamp upon the leather or other material. Throw or let the lever go back sharply and take out the book. If the block be of such a design that it must not be inverted, the whole of the covers must be blocked on one side first, and the block turned round for the other side, or the design will be upside down.

Work for blocking in gold does not require so much body or preparation as if it were gilt by hand. Morocco can be worked by merely washing the whole surface with a little urine or weak ammonia ; but it is safer to use a coat of glaire and water, mixed in proportions of 1 to 3. The heat should be moderate and the working slow.

Calf should have a coat of milk and water or thin paste-water as a ground, and when dry another of glaire, both laid on evenly ; but if only portions are to be gilt, such as a centre-piece, and the rest dead, the centre-piece or other design should be pencilled in with great care. The design is first slightly blocked in blind as a guide for the glairing. The edge of the glaire always leaves a dark stain. The heat required for calf is greater than for morocco, and the working must be done more quickly.

Cloth requires no preparation whatever ; the glue beneath and the coloured matter in the cloth give quite enough adhesiveness, when the hot plate comes down, for the gold to adhere.

Calf Colouring. — Although coloured calf-skins may be bought almost as cheaply as "smooth" calf (uncoloured ones), yet there are many places where coloured calf cannot be procured. Skins may be purchased already sprinkled or marbled at most leather shops. This plan of sprinkling and marbling the whole skin is good enough for cheap or half-bound work, but for extra work it is far better to sprinkle, marble, or otherwise colour the leather when on the book. Hand-colouring is coming again into use, and by degrees getting known throughout the trade.

When an acid is used on leather, it is essential to wash as much as possible of it out with water immediately after it has done its work, or in a few months the surface of the leather will be found to be eaten away and destroyed. It is a fault of some binders, that if they use a chemical on leather or paper, they are not satisfied to have weak acid, allow it to do its work slowly, and, when the proper moment has arrived, stop its further action. They frequently use the acids as strong as possible, and neglect to wash out the residue. The consequence is, the leather or paper rots. To avoid this, the recipes given below are selected for their harmless character.

Black.—Iron sulphate (copperas) is the chief ingredient in colouring calf black. Used by itself, it gives a greyish tint, but if a coat of salts of tartar or other alkali be previously used it strikes immediately a rich purple black. It can be purchased at 1*d.* per lb.

(*a*) Into 1 qt. boiling water, throw ¼ lb. iron sulphate ; let it reboil, stand to settle, and bottle the clear liquid for use.

(*b*) Boil 1 qt. vinegar with a quantity of old iron nails or steel filings for a few minutes ; keep in a stone jar, and use the clear liquid. This can, from time to time, be boiled again with fresh vinegar ; an old iron pot must be kept for boiling the black.

Brown.—(*a*) Dissolve ¼ lb. salts of tartar (oxalic acid) in 2 pints boiling water, and bottle for use. This is mostly used for colouring ; it has a very mellow tone, and is always used before the black when a strong or deep colour is required. It is poisonous, and must not be used too strong on the calf, or it will corrode it.

(*b*) For a plain brown dye, the green shells of walnuts may be used, broken up, mixed with water, and allowed to ferment. The liquid is strained and bottled for use. A pinch of salt thrown in will help to keep it. This does not in any way corrode the leather, and produces the best uniform tint.

Yellow.—(*a*) Picric acid dissolved in water forms one of the sharpest yellows. It must not be mixed with any alkali in a dry state, as it forms a very powerful explosive compound. It may be bottled for use.

(*b*) Into a bottle put some turmeric powder, and mix well with methylated spirit; the mixture must be shaken occasionally for a few days until the whole of the colour is extracted. This is a very warm yellow, and produces a very good shade when used after salts of tartar.

For all the following a preparation or ground of paste-water must be put on the calf, that the liquids may not sink through too much. The calf must be paste-washed all over equally, and allowed to get thoroughly dry. It will then be ready for the various methods. Perhaps to wash it overnight and let it stand till next morning will be the best and surest plan. It matters very little whether the calf is on the book or in the skin.

Sprinkles. — There are many sprinkles, all worked in the same way, by throwing the colour on finely or coarsely, as it may be wanted, light or dark.

Presuming that the paste or ground-wash is thoroughly dry, take liquid salts of tartar and dilute with cold water, 1 part salts to 2 of water, in a basin; wash the calf with this liquid evenly, using a soft sponge. The calf will require the wash to be applied 2 or 3 times, until a proper and uniform tint is obtained. Each successive wash must be allowed to get thoroughly dry before the next is applied.

The next process is to sprinkle th book, with the boards open; 2 piece of flat wood, about 3 ft. long, 4 in wide, and ½ in. thick, will be foun very useful for carrying the book These rods must be supported at eac end, so that the book may be suspended between them, with the board resting on the rods nearly horizontally Put into a round pan some of th copperas fluid, and into another som of the solution of oxalic acid. Use pretty large brush for each pan, keeping each for its own fluid. Th sprinkling may be commenced. Th brushes being soaked in the fluids should be beaten out, using a broomstick to beat on before beating ove the book, unless a coarse sprinkle i desired. Whilst beating over the book, the hand should be held u high, and moved about, so that a fin and equal spray may be distributed and this should be continued until the desired depth of colour is attained.

This may be varied by putting some geometrical design, cut out of thin millboard, on the cover; or if the book is on any special subject, the subject itself put on the cover will have a very pretty effect, and may be made emblematical. A fern or other leaf for botanical work as an instance. The sprinkle must in these cases be very fine and dark for the better effect. The leaf or design, being lifted from the cover when the sprinkle is dry, will leave the ground dark sprinkle with a light brown leaf or design. "Cambridge calf" is done in this way by cutting a square panel of millboard out and laying it on the sides. The square on the cover may be left brown or may be dabbed with a sponge.

Marbles.—As the success of marbling depends upon the quickness with which it is executed, it is important that the colours, sponges, brushes, and water, should be previously disposed in order and at hand, so that either of them can be taken up instantly. Another point to which attention must be directed is the amount of colour to be thrown on, and consequently the amount that each brush should contain. If too much colour (black) is thrown on, the result will be invisible; if too little, no matter how nicely the marble is formed, it will be weak and feeble.

Marbling on leather is produced by small drops of colouring liquids, drawn (by flowing water down an inclined plane) into veins, and spread into fantastic forms resembling foliage—hence, often called "tree-marble." It requires great dexterity of hand and perfect coolness and decision, as the least hurry or want of judgment will ruin the most elaborate preparation.

To prepare the book, paste-wash it evenly all over, and, to further equalise the paste-water, pass the palm of the hand over the board after washing it. When dry, wash over with a solution of oxalic acid 2 or 3 times to get the desired tint. When dry, glaire the whole as even as possible, and to diminish the froth that the sponge may occasion, put a few drops of milk into the glaire. Again, allow it to dry thoroughly. Put some fresh copperas into a pan, and some solution of oxalic acid into another, and soak each brush in its liquid. Place the book upon the rods, the boards extending over and the book hanging between. Should it be desired to let the marble run from back to fore-edge the back must be elevated a little, and the rods supporting the boards must be level from end to end. The elevation must be very slight, or the water will run off too quickly.

Place a pail of water close at hand; in it a sponge for washing off, and a bunch of birch to throw the water with. A little soda should be added to soften the water. Charge each brush well and knock out the superfluous colour until a fine spray comes from it. A little oil put on the palm of the hand, and the brush well rubbed into it, will greatly assist the flow of colour from the brush, and prevent the black colour from frothing. Throw some water over the cover in blotches with the birch, just sufficient to make them unite, and flow downwards together. Now sprinkle some black by beating the brush on a press pin, evenly and finely. When sufficient has been thrown on, beat the brown in like manner over the extended boards. When the veins are well struck into the leather, sponge the whole well with clean water. Have no fear in doing this, as it will not wash off. Then set the book up to dry.

Tree-marbles.—The cover is prepared and sprinkled in the same manner as in marbling; the boards, however, must be bent a little, and water applied by a sponge in the centre of each to give the necessary flow; when the water is thrown on, it will flow towards the centre or lowest part of the boards, and when the sprinkle is thrown on, a "tree," as it were, will be formed. The centre, being white, forms the stem, and from it branches will be formed by the gradual flow of the streams of water as they run down.

For marbling, everything must be ready at hand before any water is thrown on, so that the water may not have time to run off before the colour is applied. The water must run at the same time that the spray is falling or a failure will be the result.

Dabs.—This is a process with a sponge, charged with the black or the brown liquid, dabbed on the calf either all over the cover or in successive order. Give the proper preparation to the calf, and be very careful that the ground tint of brown is even. Take a sponge of an open nature, so that the grain is pleasant to the eye; fill it with black, squeeze out again, and dab it carefully over the calf. Repeat the operation with another sponge charged with brown. Cats' paw, French dab, and other variously named operations all emanate from the sponge. When done properly, this has a very good effect, and gives great relief to the eye when placed with a number of other books.

All marbles and sprinkles require

practice, so that a first failure must not be regarded with discouragement. When one's hand has got into the method with 2 or 3 colours, it is astonishing how many different styles may be produced. In all this manipulation, a better effect is obtained if a yellow tint is washed over the leather after the sprinkle or marble has been produced. Again, by taking coloured calf and treating it in the same manner as white, some very pleasant effects are brought out; and when the colours are well chosen the result is very good. Take for instance a green calf and marble a tree upon it, or take a light slate colour and dab it all over with black and brown.

In all operations with copperas, care must be taken that it does not get on the clothes, as it leaves an iron stain that cannot be easily got rid of. Keep a basin for each colour, and when done with wash it out with clean water. The same with the sponges; keep them as clean as possible; have a sponge for each colour, and use it only for that colour. A piece of glass to put the sponges on will be of great use, and prevent the worktable or board from catching any of the colour. A damp book or damp paper laid on a board that has been so stained will most probably be damaged, even though it has waste paper between the work-board and book. No amount of washing will ever take away such a stain.

When the book has been coloured, the edges and inside are blacked or browned according to taste, or in keeping with the outside.

Substitute for Brass Lettering.—Place an open vessel half-full of water on the fire, and let it boil, and set a small empty tin pot floating within it, loading the pot with some weight that it may sink low in the water. Obtain some ordinary printing types and arrange them in the required order as a compositor would, in one of those brass frames with wooden handles used for marking linen, and screw them tight in their place, taking care to have them all level with each other on the face. Lay the face of the types in the tin pot, in which some simple contrivance should be placed to prevent their being damaged, and let them get as hot as they will, as in this situation they cannot get too hot. Cut a piece of real morocco leather larger than the size of the label wanted, breathe on it, and give it one coat of glaire; when the glaire is dry rub it slightly over with the oil-rag, and lay on the centre enough leaf gold to receive the impression of the types; place the label on a rather hard pad, and stamp the types on the gold with a sharp even pressure.

On wiping off the gold with the rag, the impression of the type remains clear and full, and if well done is far more close and distinct than anything which can be done by the most expert finisher with the brass letters of the bookbinder. The label is now cut to the proper size, and pasted evenly in its place on the back of the volume; to look well, it should be pared round the edges with a sharp knife until the extreme edge is as thin as paper. After it is dry, a gold fillet may be passed over the juncture of morocco with the calf or other leather by way of finish. The above is the easiest mode of lettering for the amateur, but it is practicable only on real morocco, the heat which can be imparted to printers' metal by hot water not being sufficient to burn the gold into ordinary leather; it is, however, a permanent method.

Repairing Books.—Re-casing is done in the following manner: Open both boards back until they touch each other, allowing the book to stand upon one end, as shown at Fig. 70; insert a sharp knife at the back between the case and the book, and cut carefully down one side through the lining (and tapes or cords, if any), then down the other side; this will separate the book from the case. The case may now be laid aside, and the book taken to pieces. Begin by laying the book upon the bench with the front up. The back will thus be at the left-hand. Lift the half of the end-paper which still adheres to the book, and gently but firmly remove it, laying it over to the left hand, with the face down. Do not throw it away; in the meantime it will keep the title-page clean. Now turn over leaf by leaf until you come to a signature: this is a letter or a number at the bottom right-hand page of every section. The first to which you will come is likely to be B after the title and contents. When you have found this, give it a gentle pull, first from the head, then from the tail; this will expose the thread with which the book has been sewn; cut this thread all the way down with a knife, and so separate the sheet from the rest of the book. Now open this sheet at the centre, and remove the threads which will be found; then scrape off the glue from the back of the sheet, and lay it down upon the end-paper *face down* at the left-hand. Go through the book in the same way, looking always for the signatures, which will follow in alphabetical or numerical order. If divided at any other place the sheet will be torn, which should be carefully avoided. It may, however, happen that a sheet has been torn even before the "taking-down" was commenced; in that case, "tip" the leaf or leaves with paste, and lay it carefully along the back of the other part of the section. Leaves thus pasted do not open up to the back like the other leaves of the book, and this may be an objection to some people. A narrow strip of tissue-paper will join two leaves together nicely; they can then be placed in the book, and will open up as well as any other leaf. If a leaf is torn across the page, take a little paste upon the finger and paste the edges of the torn part; place a strip of tissue along the tear, both sides, and leave it to dry. It can then be torn away, and in doing so the tissue will skin or split, and leave sufficient sticking along where it was pasted to thoroughly mend the tear. Music is mended in this way, but it will be best to paste the tissue all over, and leave it upon the leaf; the heavy printing of the music shows through well enough to be read, and the mend is hardly seen at all.

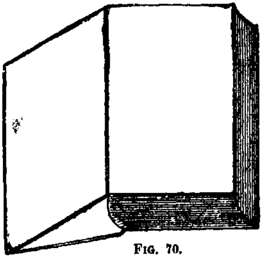

FIG. 70.

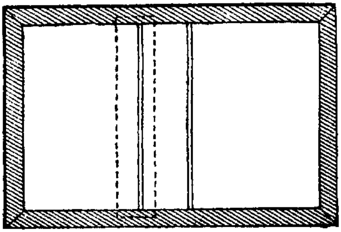

FIG. 71.

Dog-ears can be taken out of the leaves of a book by damping them slightly with the tongue, as the most ready means, and pinching them across the corner with the finger and thumb.

When the book has been all taken down, the joint is hammered out of it—i.e. you will find some of the sections bent at the back, hammer these flat. When this is done it is knocked up straight and sawn in for three bands, and sewn as already directed. The case should now be cleaned inside, all the old lining should be striped off, the back strengthened by putting a strip of strong brown paper upon it. The book is end-papered, lined, and put into the case; the directions for which have already been given.

If a cloth case is torn at the joint, do not attempt to mend it by *sewing it*, or even gluing a piece of cloth on the outside of the cover. Take it off the book, and insert a flat knife along the broken part to raise the cloth from the board; cut a strip of binders' cloth as near the colour of the case as possible. Glue it, and slip it in below the part you have raised, glued side to the board, of course; allow it to be broad enough to come into the back about half-way, rub it down well. Now glue the part which was raised off the cover with the finger, and lay it down neatly upon the new piece. The dotted lines in Fig. 71 will show the position of the patch, which *must* be between the board and the cover. A corner may be patched in the same way by lifting the cover and slipping the patch under. If patches of cloth are put on the top of the cover, they will peel off in no time, and will require continual sticking down.

Cloth cases which have become faded or spotted by rain or otherwise, may be freshened up by washing with diluted glaire, about half and half glaire and water. A large sponge should be used, and the gilded parts avoided as well as possible. The glaire dims the gold. After the book has become thoroughly dry, it should be rubbed lightly all over with a piece of pure rubber (not the vulcanised stuff that is used for cleaning paper); this will take away remaining dirt, and brighten up the gold a little.

Leather-bound books are treated much the same. If the board is torn away at the joint, treat it exactly as directed for the cloth book: Take away the case and patch it with a piece of leather same colour as the original cover, putting it between the cover and the board; if both boards are torn, remove them and the old back as carefully as possible; raise up the leather along the back of the old boards, put on a new piece (bringing it over on both sides), turn it in, and lay down the old cover upon the top, pasting it well, and, when thoroughly dry, paste on the old back upon the new one. The book will also require new end papers. These can be put in from the directions already given. Instead of washing leather covers with glaire, use paste-water. When dry, a coat of thin shellac varnish will improve the appearance.

It is, unfortunately, impossible to regild them unless they are taken to the original binder, who alone has the necessary tools. New lettering-pieces, however, may be made at any binder's, the cost of which would only be a few pence, and put on over the old one, or the old one may be removed entirely and the new one put in its place.

Photographic albums are a source of much trouble as the cheaper sorts are after a few weeks' usage very much dilapidated.

They may, however, be patched and mended to look as good as new, and may even be made stronger than they were at first. The point of weakness in albums is the joints. Each leaf has, or should have, a joint. In the better kinds these joints are made of cloth or leather. You will observe that these joints are placed underneath the paper forming the leaves. When patching a leaf, remove the paper carefully, or rather raise it from the joint, take out the old one and put in the new one, whether it is leather or cloth, and paste the paper down again. Go over every leaf carefully, and put in new joints where required. Take the album out of the case. This is easily done, as the end paper is thick, and only sticking to the board at the edges.

If there has been a lining on the back, take it off, and straighten every leaf. You will find them shift about in all ways if moved by the fingers. Glue the back well with good strong glue, not too thick, and cut a piece of strong linen the length of the back and about 2 in. broader; glue this and put it on the back, allowing 1 in. to come on each side. Take care to make this stick well to the back by rubbing it closely with a folder or the handle of a tooth-brush. Strengthen the back of the case by glueing a strip of brown paper inside. Place the album in the case again, glue the end-papers, and put it in the press. Leave the back open, for if glued to the album it will not open freely, and the leaves will stand up instead of lying flat.

The leaves are often slit where the cards are put in. These can be mended as the leaves of a book are mended; description already given. ('Eng. Mech.')

BRIQUETTES (BLOCK-FUEL).

CONSIDERING the vast quantities of inflammable waste material that exist and are either destroyed or disposed of at nominal prices, it is to be wondered at that the Briquette industry is not in evidence to a greater extent than it now is. Of course waste material of this kind is not always near towns, and in the case of sawdust it is almost confined to remote districts where lumber mills exist. In the case of coal dust, however, this is more readily available, while peat is, in many parts, available in bulk near centres of civilization. Probably peat is the most difficult to deal with, but owing to its availability and unlimited quantity every effort is being made to perfect its conversion into a solid coal-like fuel.

Coal-Dust Briquettes.—(*a*) The ingredients required are coal-dust and any binding material easily procured. Clay can be used for binding a cheap article, but has the fault of caking in a hot fire, and rendering the ash very difficult to remove.

The process in general use is to have steam jacketed pans, and to mix with the coal-dust, a certain proportion of resin, pitch, and crude naphtha, and after these articles have undergone a thorough mixing they are let out through a door at the bottom of the pan, and passed on to a press. In this, they are pressed into blocks of a suitable size, and, on leaving it, they are ready for the market.

If clay is used as a binding material, it greatly improves the look of the product if it is finished off with a coat of crude resin, by melting the resin and dipping the blocks into it.

There is very little skill required in the production of these goods, when once the proper proportions of the different ingredients are obtained.

Almost any resinous or tarry matter may be used in the manufacture. Seaweed, boiled down in water, may be advantageously employed when collieries are situated near the coast. The weed on being boiled for some hours produces a glutinous mass, and acts as a good binding material; it should be mixed with the coal dust in the pan. Pine saw-dust, 7½ per cent. mixed with the coal-dust before going into the pan improves the quality of the briquettes. Any kind of sawdust may be used, but pine is the best, owing to its resinous nature. The quantity of each binding material necessary can be best ascertained by experiment and presents no difficulty.

(*b*) There are two ways of treating coal-dust for briquettes, one with heat and one without. With heat it is necessary to have some kind of boiling pan such as those used for boiling asphalt or for tar paving. The dust is put in this with 18 lb. of coal-tar pitch to each 100 lb. of coal-dust. They are well heated and worked with a paddle so that the two ingredients may blend as perfectly as possible. When the mixture appears to be ready, it is taken out in suitable amounts and filled into moulds. No pressure is required, but the moulds must be well filled. In some cases moulds are dispensed with, the material being patted or beaten into blocks with wooden bats; or, occasionally, the briquette is preferred ball-shaped, about the size of a very large orange.

The cold method requires coal-dust and coal-tar, no pitch being required as this needs heat to make it fluid. The coal-dust may be put into a pan or tank, or it may be made into a heap in the open. A space is then formed in the middle and the tar poured into this. It is then worked with a shovel or paddle to the consistency of stiff mortar, then put direct into the moulds, or beaten into blocks, or rolled into balls, as just explained. These take longer to become hard than the hot process. An economy can be effected by using part tar and part water for the liquid ingredient. The utmost proportion of water is one part to each two parts of tar. The total quantity of fluid required for the coal-dust must be judged by the mixer, he adding a little at the time like mixing mortar or concrete.

Sawdust Briquettes.—Sawdust in cake form appears to have been used as fuel in Germany with rather promising results. United States Consul, A. L. Frankenthal, writing from Berne, Switzerland, says that the sawdust cakes are octagon-shaped, 6½ in. long, 3⅛ in. wide, and ¾ in. thick, weighing about half a pound each. In the district surrounding the factory where these cakes were made the schools were heated by them, the combustion leaving very little ash and proceeding without a large flame. No binding ingredient is said to be used, the sawdust being simply dried and pressed into the desired briquette shape, and owing thus to the absence of tarry or oily substances there is no smoke in burning. The weight of such a briquette indicates the heavy pressure under which it takes its shape, and the edges look like polished oak; in fact, it is heavier than a piece of hard wood of the same size. The demand created by the popularity of the fuel exceeded the supply of sawdust obtainable in the vicinity of the factory, and carloads were, therefore, procured from Sweden, and other distant manufactories. Sawdust, which previously could be had for the asking, demanded a market price as soon as it became known that a certain factory could make use of it. Even then it was profitable to manufacture the briquettes; but, unfortunately, the factory was destroyed by fire, and operations came to a standstill. Making sawdust briquettes of this kind would, therefore, seem to be worth inquiring into further.

Peat Briquettes.—(*a*) During the past fifty years this industry has been placed on a more intelligent basis, due chiefly to the solution of the problem of a cheap production on a large scale. At the present day machine peat is made which stands transportation and the influences of weather, and in many localities even competes with coal. According to a report by the American Institute of Mining Engineers, the method of making machine peat is entirely automatic, the machinery for cutting the peat, elevating it to the press, and conveying the slabs to the drying ground being mounted on a truck which travels into the bog sometimes under its own steam. This arrangement is made for a capacity of from 50 to 80 tons in 24 hours, and costs from 800*l*. to 1200*l*. at the factory. The truck travels on rails, and the bog is gradually exhausted by cutting each new trench next to the one just completed. An excavating elevator drops the raw peat into the machine, where it is disintegrated, kneaded, and forced through a mouthpiece in the form of an endless plastic band, upon a truck on which it is cut, by a series of adjustable knives, into any desired lengths. The pressure required is very slight, and as no water escapes, the chemical composition of the raw material is unchanged. The volume of the peat is reduced about one-half, and the slabs when thoroughly air-dried weigh from 40 lb. to 60 lb. per cub. ft. One man is employed for every 2 or 2½ tons of peat briquettes produced. While the raw peat contains as a rule, between 80 and 90 per cent. of moisture, the air-dried slabs have seldom more than from 15 to 25 per cent. To effect a more thorough drying, large hot-air chambers are used.

The cost of making machine peat in Germany is from 3*s.* to 4*s.* per ton at the outset, which allows a considerable depreciation for the machinery. This figure is taken from the Schilt Works, near Oldenburg, and from the Rainbow Works, near Langen, on the Elbe. There is a peat bog at Magdeburg which yields annually about 540*l.* worth of machine peat per acre, while the cost of manufacture is but 180*l.*, thus leaving a profit of 360*l.* per acre. The average depth of this bog is 40 ft. The experience gained with the use of press-peat as locomotive fuel in Bavaria, Austria, Sweden, Russia, and Ireland is stated to be very satisfactory. The utilisation of dried press-peat for gas making and as a substitute for coal and charcoal is also stated to be satisfactory. The problem to produce from a poor grade of fuel containing from 70 to 90 per cent. of moisture, a briquette which can compete with coal, or can make up deficiences in the fuel supply, is a very serious one. Huge masses of raw material have to be handled and cleansed from foreign matter, and tons of water have to be expelled in order to obtain a limited quantity of valuable fuel. Many processes have been tried and abandoned, as they proved to be too expensive. A few plants in Germany and Holland are working on similar lines with brown coal, but a large portion of the water is expelled mechanically before drying by heat. Much labour and money have been expended in Germany on the development of the peat industry, and nearly all modern methods have originated in that country. Great efforts are being made to establish the manufacture of solid peat briquettes as a permanent commercial industry. In Holland there are many acres of peat bog excavators under cultivation, and supporting from 300 to 350 people per square mile. In some water-filled bog trenches fisheries are established on a large scale.—'Journal of the Society of Arts.'

(*b*) An improved peat briquette is being made at Charlton, Kent. The chief novelty lies in the method of expelling the water from the raw material. The peat, as it comes from the ground, is inserted into a vertical cylinder, perforated at its surface and made to revolve rapidly about its vertical axis. Electricity is used in the expelling process, a current being caused to pass from the axis, through the peat, to the surface of the cylinder, being conducted away by brushes. The effect of the current is to loosen the fibres of the peat, release moisture, and so allow of a more free and perfect escape of water. The water, as will be understood, is thrown off by centrifugal force when the cylinder is rotated. The electric current is considered to have a breaking up effect on the fibres so that the subsequent compression of the treated material produces a solid and fairly hard block.

Of course briquettes, of whatever combustible they may be made, will serve a useful purpose for fuel, so that their practicability is confined to the question of cost. A good peat briquette can produce but half the heat units per pound that good steam coal will, so that 2 lb. of best peat fuel may be required in place of 1 lb. of coal, and, in addition, the peat has a greater bulk for a given weight. It would seem, therefore, that in treating peat for this purpose, the cost must be very carefully considered, and when power for both water expulsion and electrical treatment must be provided, the difference between profit and loss on the product will need very carefully going into.

* * *

BURNISHING.

To burnish an article is to polish it by removing the small roughness upon its surface; and this is performed by a burnisher. This mode of polishing is the most expeditious, and gives the greatest lustre to a polished body. It removes the marks left by the emery, putty, or other polishing materials; and gives to the burnished articles a black lustre, resembling that of looking-glass. The form and construction of the burnisher is extremely variable, according to the respective trades; and it must be adapted to the various kinds of work in the same art. In general, this tool is only intended to efface inequalities. Whatever substance the burnisher is made of is of little consequence to the article burnished, provided only that it is of a harder substance than that article.

Burnishers.—The burnishers used are of two kinds, of steel and of hard stone. They are either curved or straight, rounded or pointed, and made so as to suit the projecting parts, or the hollows of the piece. Stone burnishers are made of blood-stone, cut, and either rounded with the grindstone, or rubbed, so that they present, at the bottom, a very blunt edge, or sometimes a rounded surface. These are polished with emery, like steel burnishers, and are finished by being rubbed upon a leather, covered with crocus martis. The stone is mounted in a wooden handle, and firmly fixed by a copper ferrule, which encircles both the stone and the wood. The best blood-stones are those which contain the most iron, and which, when polished, present a steel colour.

Mode of Operation.—The operation of burnishing is very simple; take hold of the tool very near to the stone, and lean very hard with it on those parts which are to be burnished, causing it to glide by a backward and forward movement, without taking it off the piece. When it is requisite that the hand should pass over a large surface at once, without losing its point of support on the work-bench, in taking hold of the burnisher be careful to place it just underneath the little finger. By this means the work is done quicker, and the tool is more solidly fixed in the hand. During the whole process, the tool must be continually moistened with black soapsuds. The water with which it is frequently wetted causes it to glide more easily over the work, prevents it from heating, and facilitates its action. The black soap, containing more alkali than the common soap, acts with greater strength in cleansing off any greasiness which might still remain on the surface; it also more readily detaches the spots which would spoil the beauty of the burnishing. In consequence of the friction the burnisher soon loses its bite, and slips over the surface of the article as if it were oily. In order to restore its action, it must be rubbed, from time to time, on the leather. The leather is fixed on a piece of hard wood, with shallow furrows along it. There are generally two leathers—one made of sole leather and the other of buff leather. The first is impregnated with a little oil and crocus martis, and is particularly used for the blood-stone burnishers; the other has only a little putty of tin scattered in the furrows, and is intended exclusively for rubbing steel burnishers, as they are not so hard as the blood-stone. Blood-stone being very hard, the workman uses it whenever he can, in preference to the steel burnisher. It is only in small articles, and in difficult places, that steel burnishers are used, as they, by their variety of form, are adapted to all kinds of work. In general, the blood-stone greatly reduces the labour.

When the articles, on account of their minuteness or from any other cause, cannot be conveniently held in the hand, they are fixed in a convenient frame on the bench, but under all circumstances be very careful to manage the burnisher so as to leave untouched those parts of the work which are intended to remain dull. When in burnishing an article which is plated or lined with silver, there is any place where the layer of precious metal is removed, restore it by silvering these places with a composition supplied by the silverer, which is applied with a brush, rubbing the part well, and wiping it afterwards with an old linen cloth. The burnishing being finished, remove the soapsuds which still adhere to the surface of the work; this is effected by rubbing it with a piece of old linen cloth. But when there are a great number of small pieces to finish, to throw them into soapsuds and dry them afterwards with sawdust is more expeditious.

The burnishing of gold leaf or silver, on wood, is performed with burnishers made of dogs' teeth, or agates, mounted in iron or wooden handles. When about to burnish gold, applied on other metals, dip the blood-stone burnisher into vinegar; this kind being exclusively used for that purpose. But when burnishing leaf-gold on prepared surfaces of wood, keep the stone, or tooth, perfectly dry.

The burnisher used by leather gilders is a hard polished stone, mounted in a wooden handle—this is to sleek or smooth the leather.

The ordinary engravers' burnisher is a blade of steel, made thin at one end, to fit into a small handle to hold it by. The part in the middle of the blade is rounded on the convex side, and is also a little curved. The rounded part must be well polished, and the tool be very hard. This burnisher is used to give the last polish to such parts of copper and steel plates as may have been accidentally scratched, or specked, where false lines are to be removed, and also to lighten in a small degree such parts as have been too deeply etched or graved.

In clockmaking, those pieces or parts are burnished which, on account of their size or form, cannot be conveniently polished. The burnishers are of various forms and sizes; they are all made of cast steel, very hard, and well polished; some are formed like sage-leaf files, others like common files—the first are used to burnish screws, and pieces of brass; the others are used for flat pieces. The clockmakers have also very small ones of this kind, to burnish their pivots—they are called pivot burnishers.

Burnishing Cutlery.—The burnishing of cutlery is executed by hand or vice burnishers; they are all made of fine steel, hardened, and well polished. The first kind have nothing particular in their construction; but vice burnishers are formed and mounted in a very different manner. On a long piece of wood, placed horizontally in the vice, is fixed another piece, as long, but bent in the form of a bow, the concavity of which is turned downwards. These two pieces are united at one of their extremities by a pin and a hook, which allows the upper piece to move freely around this point as a centre. The burnisher is fixed in the middle of this bent piece, and it is made more or less projecting, by the greater or lesser length which is given to its base. The movable piece of wood, at the extremity opposite to the hook, is furnished with a handle, which serves the workman as a lever. This position allows the burnisher to rest with greater force against the article to be burnished, which is placed on the fixed piece of wood. The burnisher has either the form of the face of a round-headed hammer, well polished, to burnish those pieces which are plain or convex; or the form of two cones opposed at their summits, with their bases rounded, to burnish those pieces which are concave or ring-shaped.

Burnishing Pewter.—The burnishing of pewter articles is done after the work has been turned, or finished off with a scraper—the burnishers are of different kinds, for burnishing articles either by hand, or in the lathe; they are all of steel, and while in use are rubbed with putty powder on leather, and moistened with soapsuds.

Burnishing Silver.—Commence by cleaning off any kind of dirt which the surface of the silver articles had contracted whilst making, as that would entirely spoil the burnishing. For this purpose take pumice powder, and with a brush, made very wet in strong soapsuds, rub the various parts of the work, even those parts which are to remain dull, which, nevertheless, receive thus a beautiful white appearance; wipe with an old linen cloth, and proceed to the burnishing. (*See also* BOOKBINDING and GILDING.)

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Cameo Cutting.

Take the common helmet, or the red helmet shell (those shells whose inner surface is pink or dark coloured are most suitable), cut them into squares with a lapidary's mill, round off the corners, and shape them into an oval on a wet grindstone. Fix the enamel side on a short stick with jeweller's cement, grind off the brittle surface, sketch the subject with a black-lead pencil, cut the subject with engraver's tools, namely, a chisel tool to clear the bare places; a lozenge-shape for forming the subject, and a scraper, made of a three-angled file, ground off taper to the point, for cleaning the enamel surface round the subject, and also for forming the lineaments and other delicate parts. The colour on the cheeks and hair is produced by leaving the layer of coloured shell on those places. The stick must be grasped in the left hand, and held firmly against a steady bench, and with the tool resting in the hollow of the right hand, dig away the shell. A convenient length for the tools is 3¼ in.; they must be kept in good condition to work with accuracy. The cameos are polished with a cedar stick, or a piece of cork dipped in oil of vitriol and putty powder, and cleaned with soap and water. Mother-of-pearl is carved in the same way.

Camera Lucida.

(1) The camera lucida is an apparatus which renders great services to landscape painters by permitting them to see upon their canvas or drawing-paper the landscape that they wish to reproduce, and to sketch its outlines with an accuracy and rapidity that cannot be attained by means of the unaided eyesight. For reducing or enlarging drawings, maps, plans, etc., the camera lucida also gives excellent results. In short, this instrument forms part of the professional tools of the majority of artists, designers, engravers, etc.

The cameræ lucidæ invented by Wollaston have since been more or less improved upon, but all are based upon the same principle. They consist of a right-angled triangular prism, one of whose faces is covered with a small mirror. The rays, proceeding from the object whose image it is desired to see, first meet the prism, where they are refracted at their entrance and exit, and then strike the mirror, and from this are reflected so that the draughtsman receives them in the direction of the sheet upon which he wishes to draw, and is thus enabled to trace their contours with a pencil. But a Wollaston camera lucida is expensive. Now it is possible to obtain the same effects as are given by this apparatus, by using a simple mirror, or any bit of silvered glass, this fact being due to a physiological peculiarity of our vision.

When we look at an object, each of our eyes perceives its image, but the two images are superposed, and we thus have a perception of but a single object. If, by a slight pressure upon one of our eyes, we move the globe of the latter, while looking at the same object, the two images will be perceived separately, or, in other words, we shall see double.

It is probable that animals whose eyes have different directions, those for example that have eyes at the side, like many herbivora (hares, gazelles, etc.), or that carry them upon peduncles like crustaceans), do not perceive superposed images as we do.

It is due to such superposition of images that when we station ourselves before a sheet of white paper affixed to a wall, and turn so as to face it, it is possible, by looking with one eye into a small mirror, to see upon the paper, by means of the other eye, a reflection of the object situated behind us, and to thus easily follow or trace its outlines. It is a very simple matter to get up a camera lucida upon this principle.

As for the arrangement of the apparatus, we may affix a small mirror with wire to the cover of an open sketch-book, and so place ourselves that we may, with the left eye regarding the mirror, see with the right a reflection of the object that we desire to draw. This image will be seen upon the vertical part of the drawing paper in front of us, and we may then follow it in all its outlines and details, as we would do with an ordinary camera lucida. ('La Nature.')

(2) *Camera Lucida for the Microscope.*—In all forms of camera lucida are more or less defects, such as limitation of field, distortion, indistinctness of image or of drawing-point, awkwardness of position, etc. Being engaged in endeavouring to simplify and perfect the construction and adjustment of Wenham's high-power binocular prism, it occurred to me that his arrangement of prisms might be modified, so as to be available as a camera lucida in which the defects of the forms hitherto made would be considerably reduced if not entirely eliminated.

Assuming a 45° inclination of the microscope to be the position most generally convenient for drawing, I drew on a large scale the system of prisms which appeared to be suitable for a camera lucida. Messrs. Ross undertook to construct the prisms to my drawings, and the apparatus was found upon trial to answer my expectations fully. I am induced to describe it, because it has also met with much approbation from microscopists, who were previously disinclined to believe in the possibility of any new device at the present day, which should be substantially better than the numerous older forms which apparently exhausted the subject.

It is well known that all forms of reflecting prisms acting by means of *one* reflection are extremely sensitive in regard to the position of the mirror in relation to the microscope, as also in a less degree in relation to the eye; the slightest deviation from the normal position in many cases entirely destroying the effectiveness of the apparatus. For this reason cameræ lucidæ acting by *one* reflection have not found favour, though their apparent simplicity has induced the construction of many such forms.

In order to obviate the difficulties incident to the use of *one* reflection; many devices have been made acting by *two* reflections, and where these have been so contrived as to act like parallel mirrors, the reflected image has possessed the advantage peculiar to this principle, of being practically insensitive to slight differences of position relative to the microscope or to the eye, remaining in fact stationary within a considerable range of adjustment, as in Wollaston's camera lucida.

My device (Fig. 72) consists of a combination of a right-angled prism (Fig. 73), A B C, and a rhomboidal prism D E F G, so arranged that when adjusted very nearly in contact (i.e. separated by only a thin stratum of air) the faces B C and D E are parallel, and consequently between D E and B E they act together as a thick parallel plate of glass through which the drawing-paper is viewed. The rhomboidal prism is so constructed that when the face G F is applied at right angles to the optic axis of the microscope, the axial ray H passes without refraction to I on the internal face E F, whence it is *totally* reflected to J in the face D G. At J a part of the ray is reflected to the eye by *ordinary* reflection in the direction J K, and a part transmitted to J′ on the face of A C of the right-angled prism. Of the latter a portion is also reflected to K by ordinary reflection at J′. The hypothenuse face A C is cut at such an angle that the reflection from J′ coincides with that from J at the eye-point K, thus utilising the secondary reflection to strengthen the luminosity of the image. The angle at G is arranged so that the extreme marginal ray H′ from the field of the B eyepiece strikes upon D G at a point just beyond the angle of total reflection, the diffraction-bands at the limiting angle being faintly discernible at this edge of the field. This angle gives the greatest amount of light by *ordinary* reflection short of *total* reflection.

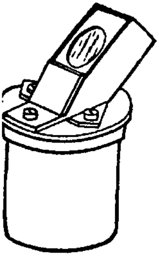

FIG. 72.

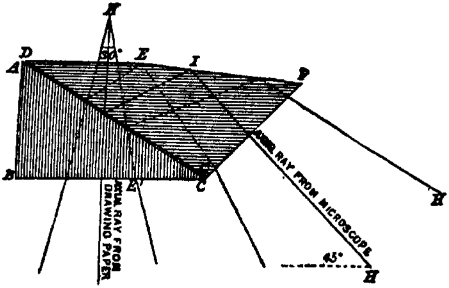

FIG. 73.

By this arrangement the Ramsden circle over the eyepiece comes just above the camera lucida, and the field of view is not in any way reduced; all that can be seen directly through the B eyepiece (say 30° of field), is perfectly depicted in the camera lucida, whilst the drawing being viewed direct is of course not cut down in field.

In practice the microscope should be inclined about 45°, and the image accurately focused through the eyepiece as usual. The camera is then slid on the eyepiece and pushed down more or less until the microscopical image is seen distinctly and the illumination of the field is equal throughout. The drawing-paper is placed on the table immediately under the camera. The observer will then see the microscopical image projected on the paper, at the same time viewing the pencil-point directly. The *whole* pupil of the eye is available for both images, the diaphragm on the apparatus being considerably larger than the pupil. It may be necessary to balance the illumination either by subduing the light in the microscope or by increasing it on the drawing-paper. It will generally be found that when the object is in a luminous field the light on the object (especially with lamplight) may be advantageously subdued by ground glass or similar means. The eye may be removed as often as required from the camera, and the work recommenced without the slightest shifting of the image; and with properly balanced illumination, fully shaded drawings can be made with very little practice. The drawing-paper should in every case be placed at the distance of distinct vision, either using spectacles or not. If the vertical position of the microscope be preferred, the drawing-paper may be inclined 45°, either in front or at the side of the instrument. For very accurate drawings in all azimuths, the drawing-paper should of course wholly coincide with the plane of the optical image, as with every other form of camera lucida. A spring clip is provided in which a screen of black paper may be put to shade the eye not in use.

This form of camera lucida can be modified so as to project the image at any desired angle. It can be used with the dissecting microscope or hand-magnifier, also on a stand for architectural or mechanical drawings. (H. Schröder.)

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CAMERA OBSCURA.

THIS simply consists of a dark chamber having a small aperture in one of its walls into which is fitted a convex lens. This simple arrangement provides for an image—a picture in natural colours, with beautiful effects—being projected on the wall of the chamber, this picture being an exact resemblance of the scenery or objects outside the chamber (on the side that the lens faces); and if suitably disposed very delightful landscape views, with moving objects (if there are any) may be obtained. The image can be received on the wall of the chamber, as mentioned, but it is more convenient to receive it on a screen (dull white in colour) as this can be placed to precisely agree with the focal length of the lens and so get the best possible definition (as with focusing in a photographic camera). For very simple purposes a small plain hole in the wall is sufficient, but does not produce the effect that a lens does, and the picture is inverted. By using a double convex lens, the picture is received correctly, and is brighter and definite. The least expensive suitable lens is one of 3 in. diameter, double convex, of 8 in. focal length, but the best results will be obtained with a photographic objective of 9 in. focus.

For artistic purposes, perhaps the image thrown on a vertical screen is sufficient, but the camera obscura, as generally exhibited, has the picture appearing on a horizontal table, and this is effected by arranging for the lens to come at a higher point and throwing its rays on a mirror placed at an angle of 45° to receive and deflect them, as Fig. 74. The mirror would be placed at precisely 45°, if the optical axis of the lens is perfectly horizontal, but otherwise the mirror and lens are adjusted to one another. The distance between the lens and the mirror is the focal length of the former. Thus with a lens of 8 in. focal length this distance would separate the two.

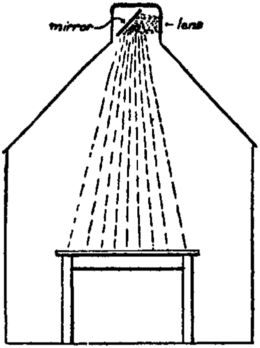

FIG. 74.

As usually arranged, the chamber is circular with a dome or pointed top, and in this top is placed the lens and mirror. If the top is made to revolve, then, of course, a great variety of views will be obtained. The chamber should be constructed of material as dark as possible so that the picture may be the more bright and real, but for special purposes a canvas bell-tent can be made to do. As regards the height, if the focus of the lens is 8 in., then the distance from the mirror to the table should be 8 ft., and this will give a picture of nearly 3 ft. diameter.

A difficulty was experienced with the early examples of this appliance in that the definition of the picture on a flat table was not regular, the centre appearing to be a little out of focus, with the edges well defined, or *vice versa*. To overcome this the table or other surface on which the picture was received, was made a little concave—i.e. saucer-shaped or hollowed out, but later experience showed that the fault was due to cheap lenses being used, for a flat table gives quite good results with a good lens.

Candles.

(*See also* Soap; Glycerine; Preparation and Uses of Oils and Fats; Etc.)

Material. *Beeswax.* — Commercial beeswax is adulterated with almost every conceivable fat, cheap paraffin, etc., as well as with "make-weights" of a coarser description; by careful sampling, a keen buyer manages to escape with about 75 per cent. of pure wax. The first operation is to boil it on weak acid water, and to separate the dross by subsidence. It is bleached either by air, or by potassium bichromate and hydrochloric acid. Thus treated, however, it becomes much more crystalline, owing to the myricin being split up into palmitic and cerotic acids. When it is air-bleached, it is melted in hot water, or by steam, in a vessel either of tinned copper or of wood, and allowed to settle; the waxy superstratum is run off while fluid into a wooden trough having a row of perforations in its bottom, by which it is distributed upon horizontal wooden cylinders, made to revolve with their lower portions surrounded by cold water. The ribbons or films made in this way are then exposed to the bleaching action of the atmosphere and the sunlight, being frequently moistened and turned over during the process. It is necessary to guard against wind, which might scatter the shreds; for this purpose, large cloths are provided. The operation is continued until the wax becomes perfectly clean and white. It is usually conducted from April till September, the exigencies of the weather preventing it at other seasons. In France, it is customary to add a little cream of tartar or alum to the water in which the wax is melted, by which the long and tedious operation of bleaching is rendered much shorter. Bleaching agents, such as chlorine, cannot be employed to bleach wax, since they render it unfit for making into candles. Purified in the above manner, beeswax is perfectly white, and has neither taste nor smell; it has a sp. gr. of from 0·960 to 0·996; at a temperature of 86° F. (30° C.) it becomes soft, and melts at 154° F. (68° C.); at 32° F. (0° C.) it is hard and brittle.

Spermaceti. — The first operation needed to fit spermaceti for use is technically termed "bagging." The crude sperm oil, as brought in by the whalers, is placed in a reservoir, at the bottom of which are a number of pipes leading into long bags lined with linen, and temporarily closed at the bottom by tying cords round the mouths. The pressure exerted by the body of material in the reservoir forces a large proportion of the oil through the pores of the sacking, leaving behind the solid or "head-matter," as a dingy brown mass. This so-called crude or "bagged" sperm is deprived of a further quantity of oil by the application of pressure. It is put into hempen bags, which are deposited between the plates of a hydraulic press. The pressure applied is about 80–90 tons. When the oil ceases to flow, the sperm is taken out, melted by heat, and then drawn off into trays to granulate. The brittle crystallised blocks are ground to a coarse powder by means of revolving cylinders; the powder is collected in a bin beneath, and is filled into cloths and subjected to a hydraulic pressure of about 200 tons. The oil expressed under this force contains a small amount of solid matters, and is therefore returned for re-bagging. The blocks, as turned out of the press, are melted down, and boiled for 2–3 hours with caustic soda lye at 22° Tw. (14° B.), in the proportion of 40 parts by measure of the former to 1½ of the latter. It is important to guard against an excess of alkali beyond that required for combination with the oil, as it would tend to saponify the spermaceti, and cause a waste of material. The mixture is kept at a low equable temperature, till the oil is taken up, and is allowed to remain at a gentle simmer, while the soap that has been formed rises to the surface and is skimmed off. The heat is then raised to about 250° F. (121° C.), and the mass is treated with small successive doses of water, the additional scum being carefully taken off as it rises, till the whole is clear. It is then drawn off to crystallise in flat tin dishes, whereupon the cakes are again reduced to powder, placed in linen bags, and subjected to a hot pressure in a very powerful hydraulic press heated by steam, after which the spermaceti will still contain a quantity of oil, or weak sperm, which no more pressure will remove, and which must be extracted by saponification. The final operation consists in boiling down the sperm with strong potash lye at 235° F. (112° C.), removing the scum as before. When the latter ceases to appear, further purification is effected by introducing a little water, at intervals, while the heat is lowered. The supernatant spermaceti, now perfectly colourless and transparent, is cast into blocks and crystallised.

Chinese Wax is produced by a small insect like a woodlouse, the *Coccus ceriferus*, whose cultivation is now an industry next to silk in importance. The statements as to the tree on which it feeds, and whose branches it covers with wax, are conflicting. *Fraxinus chinensis*, however, is certainly cultivated for the purpose. The wax melts at 180° F. (82° C.), and can be crystallised unchanged from boiling alcohol. It has a longitudinal crystalline fibre, like stearin or stearic acid, and yet possesses some of the flaky qualities of sperm.

Carnauba wax, or stone wax, is found in thin films on the leaves, stalks, and berries of a Brazilian palm, *Copernicia cerifera*. Its sp. gr. is 0·999, and its melting point 185° F. (84° C.).

Japan wax is obtained by boiling the berries of several trees of the genus *Rhus*, from incisions in the stems of which flows the famous Japan lacquer varnish. It ought properly to rank as a fat, for it consists almost entirely of glycerine palmitate, and yields glycerin upon saponification. Its sp. gr. is 0·984-93, and its melting point 120° F. (49° C.). It is largely used in vegetable-wax candles, which are made as a substitute for beeswax.

Paraffin.—The preparation and testing of paraffin scale is too large a subject for these pages, and the reader requiring information on this subject is referred to Wm. Lant Carpenter's work on soap and candles, where the subject of paraffin scale is exhaustively treated.

Ozokerit or earth wax.—The colour of this mineral varies from brown to greenish and yellow tints; its fracture is resinous. It contains about 85 per cent. of carbon, and 15 per cent. of hydrogen, and appears to consist of a group of hard, solid hydrocarbons, whose melting-points range from 140°–176° F. (60°–80° C.).

To obtain commercial products from the mineral, two processes are employed. One consists in dissolving it in some spirit, filtering the solution through charcoal, and distilling off the spirit from the filtrate. In the second, and most usual, the ozokerit is first heated with fuming sulphuric acid, and then carefully distilled with superheated steam in an apparatus.

The process of purification by acidification with strong sulphuric acid gives ceresin, a substance much resembling beeswax in consistency and fracture.

By this method, the *whole* of the mineral is converted into a homogeneous *yellow substance, without much loss,* except that due to filtration, and a certain amount of charred products. This substance (ceresin) is, however, useless in candles, as it smokes persistently. By Field and Siemssen's patent, the ozokerit is melted, and introduced directly into the still, whence it is distilled by fire heat and superheated steam. This process yields about 50 per cent. of hard white material (140° M.P.), 35 per cent. of black paraffin, 170° M.P. (employed in insulating materials for electrical purposes), and 15 per cent. of oil and soft grease (ozokerine, a substitute for vaseline).

When thus purified the ozokerit resembles fine beeswax in colour, but is more translucent than wax, though less so than paraffin. The hardness and high melting-point [142° F. (61° C.)] of the candles made from this source give rise to a drawback common to wax candles, viz. the smouldering of the wick on extinction. The immediate cause of this is the fact that the cup of the candle dries and solidifies as soon as the flame is blown out, so that there is no liquid matter left to extinguish the spark. This difficulty is now overcome by a special contrivance of the wick.

Pielsticker refines crude ozokerit by agitation first with sulphuric acid, and after treatment with barium carbonate and caustic soda.

Palm oil is distilled by methods common to the other materials noted above. The distilled mixture of palmitic and oleic acids is cut into shreds, by means of a revolving knife, and the shreds are wrapped in canvas or woollen cloths, spread in even layers between mats of cocoanut fibre, and submitted first to the cold press and afterwards to the hot press, at a temperature of 85°–90° F. (29°–32° C.). The pressed cakes of fatty acids are pared, and then melted again by steam, in large, wooden, iron-bound vessels, containing water and sulphuric acid. The whole is boiled for a time and is then allowed to stand, after which the acidulated water is drawn off. The melted fatty acids are repeatedly washed with hot water, and then run into moulds; when cold, they are quite pure, and ready for manufacture into candles, after admixture with stearic acid obtained from other fats.

Of late years, a quantity of inferior stearin (using the word in its commercial sense) has been prepared from what is technically known as "recovered grease." In spinning wool, it is necessary to lubricate it with a certain amount of oil, which afterwards has to be washed out. From these and other processes in woollen mills, large quantities of wash-waters are run to waste, containing soap in solution, and oil in suspension. In many factories, and especially in those localities where it is forbidden to pollute the rivers, these wash-waters are run into tanks, where enough mineral acid is added, to give them, after thorough agitation, a faintly acid reaction. After some hours, the contents of the tank divide themselves into (1) a greasy dirty scum, (2) clear water, (3) greasy mud on the bottom. The clear water is run away, and the residue, after draining, is packed in canvas bags and placed in hydraulic presses, which are slightly heated during the operation. Water and crude fatty acids are expressed, and separate from each other by subsidence; the fatty acids are then pressed and distilled as described above, the yellow hard portions being used for low class candles, and the oil used over again in the mill.

Wicks.—The chief essential qualities of a wick are good power of absorption, and a capacity for burning freely, evenly, and thoroughly, while producing the least possible proportion of ash. It must necessarily be quite free from inequalities of whatever kind, and should be made of perfectly sound fibres. The forms and kinds of wick differ widely with the quality and composition of the candle; the melting-points, and other characteristics of the hydrocarbons forming the candle, vary to such an extent that, in order to burn to the best advantage—or indeed, in some cases to burn at all—each sort of candle needs to be accommodated with a special wick. One of the greatest secrets of candle-making is to have the wick perfectly suited to the peculiarities of the fatty matters employed; on this score, it is impossible here to do more than indicate the principles involved.

Rush Wicks.—The original, and not yet obsolete, medium was the common soft rush, *Juncus conglomeratus*, to be found in moist pastures, and by the sides of streams and ditches. The rushes are in best condition in the height of summer, but may be gathered on to the autumn. As soon as cut, they are placed in water, otherwise they would dry and shrink, and the peel would not run. They are then stripped of half the peel, the object of which is to expose the pith sufficiently to enable it to conduct the molten fat, while enough of the rigid epidermis remains to afford it support. When duly peeled, they are laid out to bleach and take the dew for some nights, and are afterwards dried in the sun. These rushes are gathered in Lancashire, and abundantly in the Fen country, and in Ireland. Candle-wicks are ordinarily made of fine cotton yarn; Turkish cotton rovings are said to be the best, but of the cotton employed for this purpose there is certainly a great deal more imported from the United States than from Asia Minor. The wicks of night-lights vary greatly in composition, according to the fancy of the manufacturer. Sometimes little sections of rush are used, as well as very fine cotton yarn; but the majority consist of "inkle," a fine flax yarn.

Cotton and Flax Wicks.—The manufacture of cotton and flax wicks is now performed almost exclusively by machinery, the threads of fibre being bound together either by twisting or by braiding. For dip candles, the wicks require to be bulky and of loose texture, in order that the melted tallow may rise freely. They are therefore made by twisting, and constitute the simplest form of wick after rushes. The cotton yarn chosen for the purpose must be "oozy" or furry, and the threads must be free from twist. This is placed ready balled in the cutting machine. By it, the yarn is doubled in proper lengths around a rod; a knife then descends and severs the yarns, to which a twist is communicated, by means of a rolling apparatus worked by a treadle. The twist is secured by dipping the wicks at once in molten fat.

Twisted wicks have a great drawback, inasmuch as they are only very partially consumed in the flame, and thus necessitate the troublesome operation of snuffing. At the present day, plaited wicks are made flat, by which means they acquire a natural inclination to bend. For all kinds of moulded candles, plaited, or in technical language, "braided," wicks are used, the old-fashioned twisted wick being reserved for "dips."

Pickling.—After being twisted or plaited, the wicks are bleached in the ordinary way, and thoroughly dried. Before being used by the candle-maker, they are dipped in a bath of pickling liquor, the effect of which is to retard combustion, and to help in causing the destruction of the ash. The pickle most commonly employed is a solution of about 1 lb. of boracic acid in 75 pints of water; in this, the wicks are soaked for about 3 hours. When taken out, they are either wrung, or put into a centrifugal machine, to remove the first excess of water, and are then completely dried in a tinned-iron box, provided with a steam jacket, or in a room heated with steam, with racks supporting shallow trays on each side. Various other pickles are recommended; the principal are—(1) A solution of 5 to 8 grm. of boracic acid in 1 litre of water, to which 0·3 to 0·5 per cent. of sulphuric acid has been added; (2) a solution of ammonium phosphate (used in some Austrian works); (3) a solution of sal-ammoniac at 3°–4½° Tw. (2°–3° B.), proposed by Dr. Bolly; (4) a solution of 2 oz. borax, 1 oz. potassium chloride, 1 oz. potassium nitrate, and 1 oz. ammonium chloride in 3 qt. water; (5) the wicks of the newly-introduced "snuffless dips" are plaited, and are then soaked in a solution of bismuth nitrate. (6) Another good solution, in extensive use, is the following: sulphate ammonia, 1¼ lb.; nitrate of potash, ½ lb.; borax, ½ lb.; distilled water, 1 gal.; (7) J. L. Field treats wicks to prevent smouldering when extinguished, by steeping them in a solution of phosphoric acid, or ammonium phosphate, or ammonium phosphate and borax, or ammonium phosphate and boracic acid. (8) By Duparquet's process, bleached wicks are soaked for ½ hour in a bath containing 16 grm. ammonium phosphate and 7 grm. sulphuric acid at 168° Tw. (66° B.) per litre of distilled water, the acid being added when the phosphate is well dissolved. Unbleached wicks require 40 minutes' soaking, and need a preliminary cleaning in a bath of 6½ oz. volatile ammonia, 1 oz. sulphuric acid at 168° Tw. (66° B.) in 246 oz. water, the mixture being boiled by steam, and the wicks kept in for 1½ hour, then boiled for ½ hour in pure water, rinsed in cold water, wrung, and dried, ready for the second bath.

Proportions of Wick and Candle.—To get the best results there must be a careful adjustment of the size of the wick to the diameter of the candle of which it is to form a part. The size nomenclature of candles is based on the number of candles required to make up a pound weight, modified, so as to indicate differences in length required to meet the popular demand. Thus there are 6's, short 6's, and short short 6's, and other sizes of the same weight, but of different diameter. The size of the wick also is designated by the number of threads in each fold of the plait. For example, 3–20 plait is a plait of 3 ply of 20 threads each; any departure from the usual size of the ultimate threads is indicated as special. In ordinary plait for common paraffin candles, sizes 1's and 2's will be suited with 3–18 plait, 4's and 6's with 3–14 plait, 7's to short 14's inclusive, with the exception of long 10's and long 12's, with 3–11 plait, and for these and for 16's to 20's and smaller sizes 3–8 plait will be found suitable. When a candle, protected from draughts, emits smoke in burning, the wick is too large for the quality of the material used, and the adjustment demands attention. If a wick stands bolt upright during burning, it has either been imperfectly wrung, and excess of solution has gravitated during drying to particular portions of it, or by torsion it has been deprived of its elasticity. On the other hand, a wick which bends too low, making the edge of the cup to melt away on the one side, and thereby causing guttering, may be improved by strengthening the solution. Sputtering indicates wetness of the wick caused probably from an overflow of water in the candle-moulding machine. Dry wick feels crisp to the hand, and the hank when twisted and applied to the ear, will by an abundant crepitation give unmistakable evidence of dryness. Mere dampness of a wick does not cause spluttering, but the dampness will reduce its capillarity and reduce the rate of consumption, and consequently also its illuminating power.

Manufacture. *Dipping.*—The rods supporting the twisted wicks, as they come from the twisting and cutting machine, are transferred to a frame capable of being raised and lowered at will. This commonly takes the form of a beam, but a better arrangement is seen in Fig. 75. The frame, made of iron, and capable of revolving, is so suspended that a perfectly horizontal position is always maintained, even under undue pressure at either end; in this way are secured a uniform length of candle and a plumpness at the top, which is difficult of attainment, even by skilful workmen, by the ordinary beam. Under the frame are placed troughs containing melted tallow, into which the suspended wicks are repeatedly dipped. After each dipping, the adherent fat is allowed to cool sufficiently to retain a new coating on fresh immersion. The process is renewed until the candles have grown to the proper thickness; they are then left to cool and harden. Tallow dip candles are still largely manufactured, and are much employed in mines and small factories, and by domestic servants, as well as in cottages. They are also very suitable for artisans working in draughty places, as the wicks being large are not easily extinguished. They have been largely replaced for domestic use by the small moulded "cottage composites" made from distilled fatty acids, with a self-consuming wick. There is also a dip candle made from the same material, and in the same sizes as the old tallow dip, called the "snuffless dip," which, as a candle for carrying about, is superior to the paraffin candle. It is rather more expensive than the commoner paraffin, but, by the introduction of a core of softer material, the cost may be reduced. The first operation in the manufacture of these is to wind a continuous length of plaited and prepared wick around a frame of narrow, but stout, iron hoop, bent into the shape of an oblong rectangle. All the frames are of one length, but the widths vary to suit the length of the candle required. To the upper side of this frame is temporarily attached a lath or broach corresponding in length with the frame. The dipping is done at first three or four times, and when the wicks have acquired sufficient rigidity, a knife is passed along the lower side of the frame, cutting the wicks at the lower end. The iron frame is removed, and the coated wicks are left suspended on the broach. The broaches are about 3 ft. in length, and carry 40 candles each. The candles during the process of dipping are kept apart from each other by the width of the broach; and the ends of the four broaches are caught up, and kept separate, by holes made to fit them loosely in the blocks, which serve as handles wherewith to carry them, and which, in the operation of dipping, are laid on the supporting brackets of the dipping machine. Thus 160 candles are dipped at once, making 20 lb. of 8's, 16 lb. of 12's, and so on. The dipping is continued at intervals till the required weight is attained, and which is shown at once by the perfect balance. The material in the dipping trough is, by constant additions of warmer material, kept near the point of congealation. The plant required is inexpensive, consisting mainly of frames, some of them revolving on pivots, to carry the broaches with their candles while cooling, a wheel for winding wicks on frames, and a few melting tubs.

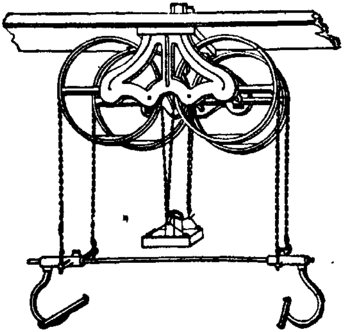

FIG. 75.—DIPPING MACHINE.

Pouring is used only with candles made of beeswax, which cannot be moulded, for the candles refuse to leave the moulds, or crack while doing so. The wicks are placed upon a horizontal hoop, and the operator, holding this with one hand, pours the previously melted wax over the wicks with the other. After three or four revolutions, that hoop is laid aside, and another is substituted. At a certain period the candles are reversed, as there is a natural tendency to thicken at the lower extremity. They are then rolled on a marble slab, under a weighted board, and are trimmed to the required length with a knife and gauge. A well-made wax candle should show rings like a tree, where the different layers have been superposed.

Moulding.—By far the greater number of candles now manufactured are moulded, by which they acquire a much more finished appearance. The most simple form of moulding machine is that known as the "hand-frame," which is in use among small manufacturers, and for particular kinds of candles, bought by those who, for reasons best known to themselves, prefer "hand-made" articles. The hand-frame contains from three to thirty-six mould-pipes (each making one candle), held together by woodwork, and opening into a trough at the top, their points being downwards. The wicks are cut to the proper length, and provided with a loop at one end, which is caught by a long crotchet-hook, and thus one wick is drawn into each pipe, where it is secured by a peg at the tip, and a cross-wire at the "butt" end of the candle. The frames are then heated to a temperature about 10° F. (5½° C.) short of the solidifying-point of the candle-material, which is then poured into them in the case of fatty acids, as cold as possible, provided that there are no lumps of solid fat in the material. The trough is filled full, to allow for the contraction of the candle when cold, and the superfluous material is eventually removed with a straight-edged trowel. The hand-made candle is readily distinguished by the little groove which the wire wick-holder makes in its base.

Arrangement of Plant.—The arrangement of the candle factory is of great importance. The boiling-up department must be well ventilated, so that the steam rising from the vats does not pervade the rest of the building, and after condensing on the roofs, drop like rain on the goods. For economy of working, it should be as central as possible in relation to the moulding room. The vats should be set at such a height that the candle-material shall, by its own weight, fall or flow into the drying pans. They must be strongly built of wood, and hooped, and each heated by a perforated copper coil inside, around, and near its bottom. On the side of each vat, near the bottom, there should be a large brass cock for running off the wax, and, in the bottom, there should be a hole, fitted with a movable plug, for drawing off the water, and below, a separator, to conserve any wax which may escape with the water. This separator may extend under several vats.

No iron must come in contact with the wax after it has been mixed with the percentage of stearic acid which has been added in the vats. The drying pans, steam cased as they must be, for heating, may be of earthenware or enamelled iron, or, as they are in rare cases, silver-plated. If these are placed in the moulding room, so as to do away with long hand carriage by the maker, the exhaust steam from them should be led away to a steam trap. The difficulty of connecting the drying pans to distant vats is the chemical one of getting a pipe or gutter of a metal or suitable material which shall not be affected by the fatty acid. This is sometimes overcome by keeping the stearic acid separate, and measuring it into the drying pans, but this method has disadvantages. Sometimes for common candles, American scale is wrought along with semi-refined. It must be blended in the melting-house, but the melting had better be done in the same way as recommended for scales for refining, at a point in the yard convenient to the stocks, where it can be done in an underground boiler, and blown into elevated settlers, whence it can be drawn as required. In blending paraffins of different melting points, they will be found to give a melting-point the mean of that of the ingredients, but the stearic acid mixture will lower it, whatever be its melting point.

Tallow Candles.—*Tallow Boiling.*—First, the fat is chopped; cutting machines are often used similar to the straw-cutting table; sometimes a thin, sharp-edged, mince-hatchet is employed, about 2½ ft. in length. This is held with both hands, and the fat, spread out on a beech block, is chopped into small pieces in all directions. A third instrument is a kind of stamp trough with muller, having a sharp blade in the form of an S, a contrivance frequently adopted for cutting beets. A more desirable instrument, however, is the ordinary rotary sausage-cutter. The fat is then placed in melting caldrons, hemispherical in form, and made of cast iron, which are heated by open fire. These caldrons are covered with movable tin-plate hoods, so adjusted that, by means of pulleys, ropes, and counter-weights, they can be easily raised or lowered, whilst, at the same time, they serve to carry off the offensive vapours arising from the heated fat. Water is sometimes mixed with the fat in the caldrons, and this addition is specially beneficial when the fat has been long kept during the summer months, and has thereby lost its natural moisture by evaporation. By gradually raising the temperature in the pan, the fat runs from the cells, and the whole is kept boiling from 1 to 1½ hour. During the whole operation of melting and boiling, the ingredients must be constantly stirred in order to keep the fat and cracklings in incessant agitation, otherwise pieces of unmelted suet, coming in contact with the sides or bottom, would become scorched and acquire a brownish tint, of which the whole melting would necessarily partake. Scorched tallow is not readily whitened. For separating the melted fat from the cracklings, it is ladled off from the caldron into a fine willow basket, or a copper box perforated at the bottom with innumerable small holes, set over large copper coolers, and allowed to remain undisturbed till all foreign matters have settled down. Before it congeals, it should be transferred into small wooden pails. This operation is continued so long as the cracklings yield any fat; and during the process the heat must be maintained at a moderate degree, to avoid scorching the materials. When the cracklings begin to harden they acquire a darkish tint, and hence are said to be browning. They are then pressed, and the fat thus obtained possesses somewhat of the brown colour of the cracklings, but not so much as to render it unfit for use as soap stock; it may, consequently, be mixed with that which has spontaneously separated while heating.

Clarifying Tallow.—(*a*) By mere melting and straining we do not obtain a fat entirely free from admixture of fine, undissolved substances. For separating these substances, it must be clarified, by remelting it in water, either on free fire or by steam. Generally, no more water than 5 per cent. is taken, and stirred well with the fat till the mixture becomes emulsive. The whole is then allowed to rest, without further heating, till the water has separated, when the fat may be drawn off, or dipped off. Sometimes, to conceal the yellowish tint, a very little blue colour is added, consisting of indigo rubbed finely with some oil, of which a few drops are sufficient for large quantities of tallow. The process of clarifying is occasionally repeated. At the line of demarcation between the water and fat, a grey slimy substance is often perceptible, and the liquid itself is turbid. Instead of pure water, some tallow-melters take brine or solutions of alum, saltpetre, chloride of ammonium, or other salts. These agents have no chemical action upon the fats, but simply induce a more rapid settling of the impurities and water, principally when strong agitation is used. (*b*) Dissolve alum 5 lb., in water 10 gal., by boiling; and when it is all dissolved, add tallow 20 lb.; continue the boiling for an hour, constantly stirring and skimming; when sufficiently cool to allow it, strain through thick muslin; then set aside to harden; when taken from the water, lay it by for a short time to drip.

Dips.—These candles are made by stringing a certain number of wicks upon a rod, and dipping them in melted tallow repeatedly. The process is very simple; the clarified and remelted tallow is poured into a tightly-joined walnut or cherry trough, 3 ft. long by 2 ft. wide, and 10 to 12 in. wide at the top, gradually diminishing to 3 or 4 in. at the bottom. A handle is fixed on each end for its easy removal, and when not in use it is closed with a cover. The operator commences by stringing 16 to 18 wicks at equal intervals on a thin wooden rod, about 2½ ft. long, and sharpened at the ends. He then takes 10 or 12 such rods and dips the wicks rapidly into the fluid tallow in a vertical direction. The tallow should be very liquid, in order that the wicks be soaked as uniformly as possible, after which the several rods are rested on the ledges of the trough, when, if any of the wicks be matted together, they are separated, and the rods so placed on a frame, having several cross-pieces, that the uncongealed tallow from the wicks may drop down, and while this is going on, which continues till the tallow is cooled and solidified, the operator is engaged in preparing another batch of rods. The fat in the trough, meanwhile, is so far cooled that in immersing the first dip again a thicker layer will adhere to the wicks. It is considered that when the tallow solidifies at the sides of the vessel, the temperature is the most convenient for the object in view. It is sometimes necessary to stir the ingredients to produce a uniform admixture, and in such cases much care should be taken so that no settlings be mingled with the mass, whilst by the addition of hot tallow any desired temperature may be obtained. The tallow on the wicks after each dipping becomes so gradually hardened, that at the third or fourth immersion new layers necessarily solidify; as a natural consequence of the method of dipping, the lower ends of the wicks become thicker than the upper, to remedy which the lower ends are again put into the melted fat for a few minutes, when the heat, as a matter of course, diminishes their dimensions. The process of dipping is continued until the candles acquire the requisite thickness. The conical spire at the upper end is formed by immersing deeper at the last dip, and if, eventually, the candles are too thick at the lower end, they are held over a slightly-heated folded copper sheet, so that the fat may melt, but not be wasted.

Moulds.—For moulding, common metal moulds, a mixture of tin and lead, are used. They are slightly tapering tubes, varying in length and dimensions according to the size of the candle to be manufactured, and, when required, are arranged in regularly-perforated wooden frames or stands, with the smaller end downwards, forming the upper or pointed part of the candle. At this smaller end, the wick, previously saturated in melted fat, is inserted, filling the aperture, and, passing up the centre, is fastened perpendicularly at the upper end of the tube, to which is attached a movable cover. The melted fat is then poured in, generally with a small can, but a tinned iron siphon is better. It is requisite that the tallow should completely fill the mould, that it should remain uncracked on cooling, and should be easily removable from the moulds. This can, however, only be obtained when the fat at the sides cools more quickly than that in the interior, and when the whole candle is rapidly cooled. A cool season is, for this reason, far better; but a certain condition of the tallow, namely, that which it possesses at a temperature very near its melting point, is absolutely necessary. Candle-makers recognize the proper consistence of the tallow for moulding by the appearance of a scum upon the surface, which forms in hot weather between 111° and 119° F., in mild weather at 108° F., and in cold about 104° F. The tallow is usually melted by itself, sometimes, however, over a solution of alum. The candles are most easily removed from the mould the day after casting, to be cut and trimmed at the base. Moulding by hand is a very tedious operation, and only practised in the smaller factories; in more extensive establishments, where economy of time and labour is a consideration, machinery is employed.

Composite Candles.—Melt together, over a water-bath, 100 parts of stearic acid, and 10 to 11 parts of bleached beeswax; but, to ensure success, the mixture must remain over the bath from 20 to 30 minutes, without being stirred or agitated. At the end of that time the fire is to be extinguished, and the fluid allowed to cool until a slight pellicle is formed on the surface, when it is cast direct into the moulds, previously heated to the same temperature, with the precaution of avoiding stirring the mixture, which would cause opaqueness.

Transparent Candles. — For 100 lb. of stock take 90 lb. of spermaceti, 5 lb. purified mutton suet, and 5 lb. wax; melt each separately over a water bath, and to the whole, when mixed together, add 2 oz. of alum and 2 oz. of bitartrate of potash in fine powder; and. while stirring constantly, raise the heat to 176° F.; then withdraw the fire and allow the mixture to cool to the temperature of 140° F. When the impurities subside, the clear liquid must be drawn off into clean pans. Paraffin wax is an excellent substitute, and much less costly. For quality and good appearance, candles made of this cooled block are more than proportional to its cost. Substitute plaited wicks for the foregoing mixture to the wicks generally used for composite candles, and prepare them by previously soaking in a solution of 4 oz. borax, 1 oz. chlorate of potash, 1 oz. nitrate of potash, and 1 oz. sal ammoniac, in 3 quarts of water. After being thoroughly dried, they are ready for moulding.

Diaphane.—This is made by melting together, in a steam-jacket, 2½ to 17½ lb. of vegetable wax, 1½ to 10½ of pressed mutton tallow, and 22 to 46 lb. of stearic acid. The latter and the vegetable wax are the hardening ingredients. By changing the proportions between the above limits, a more or less consistent mixture may be formed. The moulding is performed in the same manner as for stearic-acid candles.

CATGUT.

THIS peculiar kind of cord, of a horny substance, having immense strength and wearing qualities, is made entirely from intestines or gut. Whether those of a cat were first used, and gave the name this material bears, is not known, but the gut of practically every living creature can be put to this use. In practice, the intestines of the cow and horse down to those of the silkworm are all in large demand, the latter making the fine white gut so largely used in fishing tackle.

(*a*) Take the entrails of sheep, or any other animal, procured from the newly killed carcase. Thoroughly clean them from all impurities and from attached fat, and wash them well in clean water, soak in soft water for two days, or in winter three days, then lay them on a table and scrape them with a small plate of copper, having a semicircular hole cut in it, the edges of which must be quite smooth and not capable of cutting. Now, after washing, put them into fresh water, and there let them remain till the next day, when they are again to be scraped. Let them soak again in water for a night, and two or three hours before they are taken out add to each gallon of water 2 oz. of pearlash. They ought now to scrape quite clean from their inner mucous coat, and will consequently be much smaller in dimensions than at first. They may now be wiped dry, slightly twisted, and passed through a hole in a piece of brass, to equalise their size; as they dry, they are passed every two or three hours through other holes, each smaller than the last. When dry they will be round and well polished, and being oiled are fit for use.

(*b*) "Gut-spinning" is the twisting of prepared gut into cord of various diameter for various purposes—i.e. for ordinary catgut, for use in machinery, and for fiddle-strings. Hence in different establishments, articles of different fineness and coarseness are prepared, from the most delicate fiddle-string to a thick catgut cable. Sometimes all these varieties are made in the same establishment. The first operation, however, in every instance is the "gut-scraping."

The gut used for the above purposes is the small intestine of sheep and hogs. It is said that the sheep's small intestine measures 25 to 30 yd., and the hog's about 20 yd. The guts are collected from butchers, and in some establishments they are received from the country, or, packed with salt in barrels, from Ireland. In some establishments dried guts previously scraped are received from abroad for further manipulation. For fine purposes, such as the making of fiddle-strings, only the best and freshest guts from the butcher can be used; but for coarser purposes, their condition as to freshness is less material, and sometimes they arrive at the works in an offensive condition. The scraping is more easily effected when the gut is not quite fresh.

The first operation in gut-scraping is to get rid of the contents of the gut. For this purpose, it is thrown into a tub of water, by which a man sits, and passes the gut between his fingers into another tub of water, pressing the contents along the cavity as he proceeds. In some works, water from a tap over which an end of the gut is slipped is run through the gut. This is repeated several times until the gut is quite clean. In one case the guts are then placed in brine for 8 or 10 days, and then for 3 or 4 days in cold water.

The process of scraping is, in the larger establishments, performed by women. A bench or table is provided, at which a woman sits and scrapes the gut with a wedge-shaped piece of wood as she passes it along the table before her. In some places the back of a knife is used for this purpose. By this process all the interior softer parts are detached and pass along the gut to the end, where they are discharged, the peritoneum of the gut, and probably a little of the muscular layer, being alone left. It is again thrown into water.

The further treatment depends upon the use to which the scraped gut is to be applied. When it is to be used for sausage-skins, the scraped guts are simply packed in barrels with salt. Such as are intended far making catgut or fiddle-strings are treated further.

In some establishments, scraped guts are dried for exportation. They are stretched over frames, dried in a chamber, artificially heated, and then tied up in bundles. When dried guts are received, they are soaked in water to prepare them for spinning.

For making ordinary catgut, no further preparation is needed than sewing together lengths of scraped gut with a needle and thread. They then go to be spun by means of an ordinary spinning-wheel. The number of strands of gut spun into a cord varies with the thickness of catgut required. Catgut ½ in. thick will have as many as 700 strands of gut in it. When a length of catgut has been spun, it is dried by stretching it over pegs and exposing it (protected in some way from the weather) in the open air. Before drying, however, it is customary to bleach it by stretching it upon a frame and putting it for about 3 days into a chamber where it is exposed to the action of the fumes of burning sulphur.

The preparation of fiddle-strings is a very delicate operation, and for the finest violin strings requires the utmost care. The best scraped guts alone are used, and such as have any flaw in them are rejected. Each gut is treated separately. It is put into a clean earthenware pan containing a weak alkaline solution, and this solution is changed (a fresh pan being used each time) twice a day for 7 or 8 days, and each time the gut is transferred it is stripped through a ring formed by bending a strip of copper, or through a perforated brass thimble, the thumb being pressed upon the gut as it is passed through. After this treatment it is ready for spinning. The first strings of violins are made by twisting together 3, or better 4, such prepared guts. (Dr. Ballard.)

(*c*) The external membrane removed in the scraping process is called *filandre* by the French, and is employed for the cords of battledores and rackets, as well as for sewing together the ends of intestines. The alkaline solution for treating the fiddle-string gut is commonly made of 4 oz. caustic potash and 4 oz. carbonate of potash in 3 to 4 gal. water. The so-called "bleaching" with sulphur fumes is intended rather as a preventive of putrefaction. The twisted and smoothed cords are often finally dried for an hour in a room heated to 180° to 200° F. (82° to 93° C.). Hatters' cords, for bowstrings used in one of the stages of felt-hat making, are made from the longest and largest sheep-gut, 4 to 12 strands being used, and the ordinary length being 12 ft. In France very strong cord is prepared from the intestines of horses, asses, and mules. The scraped gut is divided into 4 equal parts by drawing it over a fixed knob with 4 sharp edges; 4 to 8 of these strips are tied at the end with packthread, twisted together, and polished with dog-skin. This cord is used as a substitute for leather belting on light machinery. About three-fourths of all the gut used in Europe is said to come from Italy. The superiority of the Italian article is ascribed to the leanness of the sheep, so that probably emaciated carcases yield the best strings.

(*d*) The putrefactive odours attending this business are a frequent cause of complaint. In no case did Dr. Ballard find a deodorant applied to such raw gut as comes in an offensive condition, nor to such as had been left to soak until offensive, for the convenience of ready scraping, nor even to the offensive refuse of the process, for the purpose of destroying their bad odour. But that the use of a chemical agent for the prevention of putrefaction in the fresh guts is admissible, and even successfully practised in some establishments in France, is shown by the following translated abstract from De Freycinet's report on trade sanitation :—

"The cleansing or separation of the peritoneal membrane, a portion only of which has been removed by the 'ungreasing' at the slaughter-house, is ordinarily performed at the conclusion of a putrid fermentation that constitutes one of the most repulsive details of this industry. This maceration, whose duration varies from 8 days to a month, according to the season, is intended to partly decompose the mucus and render it less adherent, so that the workmen may be able to detach it without risk of injuring the quality of the gut. Some manufacturers are commencing to adopt Labarraque's process, consisting in immersing the intestines in a solution of sodium chloride, which hinders all putrid fermentation. A few hours then suffice for the retting or maceration of the gut." He adds that at one works the Conseil d'Hygiène publique ordered the use of "sodium chloride at 12° to 13° B., in the proportion of about 3½ lb. in 2 or 3 buckets of water per vat containing the guts of 50 oxen."

(*e*) At Coulson's sausage factory at Cambridge, Dr. Ballard found it was the practice to immerse the fresh guts for a few days before scraping them in a weak solution of chloralum; this treatment avoids noxious odours, does not injure the gut, and does not in any way interfere with the scraping. Dr. Ballard lays down the following rules as essential for carrying on this trade without creating a nuisance: (1) A building specially erected or carefully adapted to the peculiarities of the trade, sufficiently spacious, and situated as far as practicable in a locality not closely built in. The chamber where any of the more offensive parts of the trade are conducted should have no direct communication with other rooms. It should be lighted either from the sides or roof with windows incapable of being opened, and ventilation should be provided for independently. It appears to him that the best mode of managing this would be to arrange for the drawing off of the foul air of the chamber continuously, and conducting it through a fire, or first through a screen of wood charcoal and then through a fire, and that the air for the supply of the room should be drawn from the outside through screens, or properly arranged boxes containing wood charcoal, duly protected from wet and damp, and from time to time renewed, which, when the room was shut up at night, would serve to arrest the passage outwards of offensive effluvia. The inner walls, to the height of about 6 ft., should be covered with some impervious material capable of being washed, such as smooth cement or sheet zinc. (2) The floor should be paved with an impervious paving, preferably jointless, and it should be properly sloped to a duly trapped drain gully. (3) There should be an unrestricted supply of water. (4) Scrupulous cleanliness should be observed in the conduct of the business. The floor should be kept constantly sprinkled with some deodorant solution, such as of carbolic acid or chloride of lime; no unnecessary litter should be allowed, and any that may be made should be frequently swept up, and, together with refuse matters and scrapings, should be deposited, with the addition of a deodorant, in appropriate vessels made of some impervious material, such as galvanised iron, and covered with covers of like material when not required to be open for use. At the close of each day's work, the floor and walls, to the height of the impervious portion, should be washed down with water containing some deodorant, and all tubs, tables, benches, and utensils that have been in use should be similarly cleansed. The inner walls and ceilings should be periodically lime-whited. (5) All undried gut brought upon the premises should be brought in closed impervious vessels, which should not be opened except in the chamber where they are to be manipulated, and all refuse matters should be removed from the premises daily in the closed vessels in which they are deposited. Any gut which arrives in an offensive condition should at once be placed in a deodorant solution; and some antiseptic solution should (as appears to be practicable) be used for the soaking even of fresh guts on their first arrival. (6) Great care should be taken in dealing with the refuse matters after removal from the premises. If deposited anywhere upon land, the matters should at once be covered over with a layer of fresh earth. At Calne, where the nuisance from the deposit of refuse in farm premises was at one time intolerable at a distance of several hundred yards, the nuisance has, without altering the position of the deposit, been obviated. A wall of straw litter is made, enclosing a space within which the refuse is thrown, and the offensive matter is immediately covered up with dry earth and ashes: this building up of the wall and deposit of refuse and earth is continued until a sufficient mound is raised. When it becomes necessary to remove this as manure, it is removed inoffensively. Such a stack as this should, however, be protected from the rain.

(*f*) If care is not used the trade of catgut making is peculiarly offensive, so much so that in certain instances it has been noticed that the workpeople retain a filthy odour even after changing their clothes. This, however, is due in some measure to want of cleanliness in the work and in the person, but more to the absence of disinfectants. M. Labarraque's disinfecting liquid, which is hypochlorite of soda, has been employed with great success, and this, or some of the several disinfectants that can be used without injury to the gut and at a quite small expense, should be employed. The hypochlorite of soda is said to improve the colour of the membrane without injuring its strength.

Silkworm Gut.—This substance, also called Florence gut, or simply Florence, is the fine strong fibre universally employed by anglers for attaching their hooks. Its preparation is thus described by Mrs. Whitby: There are some silkworms which come to maturity, turn yellow, but not clear, yet show no disposition to rise on the manello. The person in charge should walk round the laboratory once every morning and evening, and collect all such fat, heavy, opaque-looking creatures, and put them into a basin of half vinegar, half water; here they should be left 12 hours, and treated thus: A board should be prepared, 30 in. by 6 in., with a row of pegs at each end, and notches all round the edges. Two intestinal canals run through the length of the silkworm; these should be separated from the head of the insect while in the vinegar and water, and the threads, one by one, drawn out rapidly to their full extent, and fixed at full stretch on the board, by means of the pegs and notches. Expedition is to be observed, as the air soon hardens the strings; they must on no account be passed through the finger and thumb, as they are of no value if flat. The yellow mucilage which clings to the strings is removed afterwards by being boiled in soap and water. When the Florence (for the time being) is drawn out, the board should be placed in the sun to dry. To clean the gut, take a bit of soap the size of a nutmeg, and boil it in a gallon of water. When the soap is dissolved, put the Florence into it, and boil for 10 minutes; take it out, and pass it through cotton, to remove what may remain of the yellow matter, but pass it so lightly that the gut, which becomes soft by boiling, may not be flattened. When again stretched and dried on the board, it becomes clear and strong. Experience alone can bring this to perfection, but it is worth the trial with silkworms which will not spin, and which would therefore be lost; and, if well made, Florence should sell for ½*d.* or 1*d.* the string, according to its length, strength, roundness, and clearness." There is room for experiment on other plant-eating caterpillars with a view to utilising them in this way.

CELLULOID, AND IVORY SUBSTITUTES.

Celluloid.—(*a*) Pure celluloid is nitro-cellulose with a composition that is nearly allied to gun-cotton, and is prepared by submitting cellulose to the action of a mixture of nitric and sulphuric acids. Both cotton and paper are varieties of cellulose, and are used for making nitro-cellulose. Cheap solvents of cellulose are a mixture of methylated spirit and camphor acetone, and a mixture of amyl acetate and petroleum spirit. The two former are usually employed for rendering the celluloid plastic so that it can be moulded into shape, while the latter is used for making a transparent solution.

(*b*) In making celluloid the first operation is the preparation of a nitrated cotton, which is similar to gun-cotton. Two parts of strong sulphuric acid are mixed with 1 part of concentrated nitric acid in a shallow stoneware vat. The cotton or tissue paper is weighed out and put into small perforated jars, each provided with a lid, and when the temperature of the acids is 60° C., the jars are placed in the acid, which penetrates through the perforations to the cotton. After about forty-five minutes the jars are removed and placed in a vat of water, and fresh water is run through the vat to wash out the acid, the last traces being removed by a little ammonia or carbonate of soda. The nitrated cotton is next dried at a low temperature, and is mixed with camphor and spirit of wine or with acetone which will soften it. The mass is then kneaded and pressed into square blocks, Moulded articles are made from the plastic celluloid, but some articles are cut or turned from the solid. The celluloid soon hardens in contact with air owing to the loss of the solvent. As a rule, a little castor oil is mixed with the celluloid to make it more flexible.

(*c*) In one method of making celluloid the pyroxyline is obtained from cigarette paper of very good quality. This paper in rolls 13 in. in width and 33 to 35 lb. in weight, is unrolled mechanically and immersed in a mixture of 5 parts of sulphuric acid of 66° B., with 2 parts of nitric acid of 42° B., kept at a temperature of about 85° F. (35° C.). The cellulose of the paper after 12 or 15 minutes' immersion, becomes changed into nitrocellulose, which is soluble in a mixture of alcohol and ether. The solubility is tested by a hasty trial. The product is then removed from the acid bath, the liquid is expressed from it, and it is thrown into water. After a preliminary washing it is placed along with water in a pulp vat, and triturated for 2½ to 3 hours in order to obtain a homogeneous paste. The pyroxyline then has to undergo bleaching, the operation being effected by the use of a solution of potash permanganate. When contact with this reagent has been sufficiently prolonged, the excess of permanganate is eliminated by washing. Then the mass is treated with a solution of sulphurous acid in order to dissolve the oxide of manganese, and the operation is finished by a series of washings in water. The whitened pyroxyline is put into boxes lined with filtering cloths, and then submitted to mechanical drying. On being taken from the hydro-extractor, the material only retains about 43 per cent. of water and is found to be in a state fit for the preparation of celluloid. It is then passed through a mill having metallic runners, first alone, and afterwards mixed with the proper quantity of camphor (which has been first rolled), and with colouring matter if it be proposed to make opaque celluloid. After a dozen successive grindings, the mixture is moulded in a metal frame, by hydraulic pressure, so as to give slabs, that are arranged and pressed between 10 to 12 sheets of thick bibulous paper. The water in the mixture is then gradually absorbed by the paper, the latter being renewed 12 to 15 times. The slabs, thus dried and reduced to a thickness of about $\frac{1}{10}$ in. are broken up between bronze cylinders armed with teeth. The pieces are allowed to macerate for about 12 hours with 25 to 30 per cent. of alcohol of 96°, and then the colouring matters soluble in alcohol are added, if it be proposed to have transparent coloured celluloid. The mixture is then passed through the rolling mill, the cylinders of which are heated to about 122° F. (50° C.). The operations are performed upon 12 to 28 lb. at once. The rolling takes 25 to 35 minutes, and terminates when the material has become homogeneous. There is then obtained a sheet of about ½ in. in thickness, which is cut into pieces of 23½ by 31½ in. The latter are superposed on the table of a hydraulic press in a metallic box having double sides and being tightly closed, and allowing the heating to be done by a circulation of hot water. The box is heated to 140° F. (60° C.) during the whole duration of compression, which lasts about 4 hours. At the end of the operation, a current of cold water is passed into the box, the pressure is removed, and there is obtained a very homogeneous block of celluloid about 5 in. thick. The blocks are taken to the planing machine, and shaved into sheets varying from 0·008 to 0·12 in. in thickness according to the purpose for which the product is designed. These sheets are next placed in a ventilated stove, heated to 131° F. (55° C.), where they remain from 8 days to 3 months, according to their nature and thickness.

In this description it has been only a question of celluloid of a uniform colour, either transparent or opaque, imitating pale tortoise-shell, coral, ebony, turquoise, etc. When it is desired to obtain a product to imitate amber, jade, spotted tortoise-shell, etc., each of the ingredients, of uniform colour, which is to compose the material, is prepared separately and then mixed, to be afterwards united by pressure.

(*d*) Celluloid is also formed of divided cotton waste, or similar substance, dissolved in one or more of the following solvents: Vegetable naphtha, nitro-benzol, camphor, alcohol, and glacial acetic acid. Sufficient of these solvents is used to make a soft, plastic mass, which is then or subsequently subjected to hydraulic pressure, and mixed with oils, gums, and colours. By this means, any degree of hardness or flexibility can be given to it, and it can be made white and transparent or of brilliant colour. It can be made as hard as ivory, or retained in so soft a condition as to be spread in layers over textile fabrics much in the same way that paint is laid on. The substance is water-proof, acid-proof, and air-proof. It can be worked in a soluble, plastic, or solid state. It can be pressed and stamped, planed as wood, turned in a lathe, cut with a saw, carved, inlaid, woven into fabrics, or applied as a varnish. It can be made either transparent or opaque, and is capable of bearing a high polish. When dyed, the dye runs through the whole substance, and cannot, consequently, be rubbed or washed off.

The manufacture may be divided into two distinct stages: (1) The production of the so-called "pyroxyline;" (2) The treatment of this compound with solvents, in order to make it plastic, and give it other desired qualities. The first stage of the process suffers but little variation. A convenient quantity of cellulose or woody fibre, such as disintegrated cotton waste, paper, etc., is fed into an open vessel called a "converter," and treated with an acid mixture composed of 1 part of nitric acid, sq. gr. 1·420, and 4 to 5 parts of sulphuric acid, sq. gr. 1·845, mixed in a separate vessel, and kept as cool as possible. The acid mixture is pumped or forced up into the converter, while the fibrous substance, previously placed in a hopper over the converter, falls gradually into it by an opening in the top. The charging of the cotton into the converter occupies about 10 minutes, and at the end of 20 to 30 minutes at most, it is chemically converted into the so-called pyroxyline or nitro-cellulose. This, together with the excess of acids adhering, is then allowed to fall through an opening in the bottom of the converter, and is caught in a large box provided with a false bottom of perforated iron or wire gauze, at about 6 in. above the real bottom. On this the wet mass remains for an hour, to admit of the excess of acids draining away as far as possible; the still remaining impregnations of acid are then expressed by placing the pyroxyline in a cylinder with a perforated bottom, and subjecting it to hydraulic pressure. The result is a hard cylinder of pyroxyline, containing from 5 to

20 per cent. of the acid mixture, in which state it is stored for future use. When required, the cylinders of pyroxyline are torn into dust by special machinery, such as that employed for grinding paper pulp, and the disintegrated mass falls into a large tank, where it is well washed with water, to remove the last traces of acid. It is then again placed in the cylinders with perforated bottoms, and pressed to remove the water, leaving in from 5 to 20 per cent. The solid cylinders of soluble pyroxyline are again broken up in the disintegrating machine, preparatory for the treatment with solvents, which forms the second stage of the manufacture.

Solvents.—(1) One of the first solvents employed on a large scale was wood naphtha, distilled with chloride of lime, in the proportion of 1 gal. of the naphtha to 2 to 6 lb. of fused chloride; the more of the latter used within these limits, the stronger will the solvent be. The first 3 qt. of the distillate are collected for use; the remainder is caught in a separate vessel so long as any spirit comes over. and is distilled again at the next operation with more fresh materials. The deposit remaining behind in the still is chloride of lime, dissolved in water and contaminated with some tarry matter. It is run into an open iron vessel, heated by a fire beneath, to evaporate away the water and fuse the chloride of lime ready for re-use.

The solvent thus prepared is applied to the pyroxyline in such proportions as to make a pasty mass; but if used alone, the resulting celluloid would soon become hard and brittle. To avoid this, a certain quantity of oil is added to the mass, and kneaded up with it in the mixing machine. The proportion of oil will vary with the desired degree of toughness. To produce a consistency suitable for coating telegraph wires, or for spreading on textile fabrics, the proportion of oil may equal half the weight of the pyroxyline. If the oil used be first treated with chloride of sulphur, the compound is much more elastic. It is thus treated by mixing with 2 to 10 per cent. of liquid chloride of sulphur, according to the degree of elasticity required; but the chloride of sulphur should first be diluted with an equal bulk or more of mineral naphtha, or bisulphide of carbon, to prevent too violent action. The prepared oil is compounded with the dissolved pyroxyline in various proportions, but seldom exceeds 20 per cent.

(2) To increase the hardness and modify the colour of the product, sometimes a small portion of gum or resin, such as shellac or copal, is added, but seldom more than 5 per cent. The wood naphtha may be replaced by alcohol, and the chloride of lime by chloride of zinc, or manganese fused or dry. For economy's sake, a small quantity of light spirits from coal may be mixed with the solvent, but it is not desirable. For the oil may be substituted balata gum treated with chloride of sulphur—usually not more than 5 per cent. of the chloride. The combustibility of celluloid thus made may be corrected by the addition of chloride of zinc or tungstate of soda. Ten per cent. of either effectually prevents burning; but usually much less will do, especially when pigments are used. The same end is attained by employing iodide of cadmium, oxalate of zinc or manganese, or gelatine dissolved in glacial acetic acid.

(3) A practical difficulty attending the use of the above process is that the solvents employed are so volatile. Large masses of celluloid may be prepared better, quicker, and with less consumption of solvent by adopting nitro-benzol, aniline, or glacial acetic acid, and the celluloid may then be worked in the open air. The ordinary volatile solvents are improved by the addition of camphor.

When using nitro-benzol, the commercial article should be distilled with hydrochloric acid or chloride of lime, say 6 lb. of either to 1 gal. of nitrobenzol, which is thus rendered purer and sweeter. One hundred parts of pyroxyline are then moistened with ordinary solvent — preferably naphtha distilled chloride of lime—and the excess of solvent is removed by hydraulic pressure. The other solvent is then added in the proportion of 10 to 50 parts of prepared nitro-benzol or aniline, together with 10 to 50 parts of camphor, and 150 to 200 parts of oil, preferably cotton-seed or castor. This mixture is forced between rolls, heated by steam being admitted into them, till the whole forms a well-combined dough or paste, which will be more or less stiff according to the quantity of solvent used. For a hard compound, the oil should be less than the pyroxyline; for a soft one, it should exceed the latter—say, 150 to 200 oil to 100 pyroxyline. In making celluloid with glacial acetic acid, 100 parts of pyroxyline are dissolved in 50 parts of the acid, for a stiff paste; or 100 to 300 or more parts, for a semi-fluid consistency.

(4) Usually the pyroxyline requires to be dried before dissolving it. The conduct of this operation on large quantities requires much care and time and a very large space of drying room, so that great advantages, on the score of cost, ease, and safety, are to be derived from dissolving it in a moist state. For this purpose, the pyroxyline is prepared in the usual way, and when rendered soluble by the addition of hydrocarbon solvents, it is taken out of the acids and placed in a hydraulic machine, by which as much as possible of the acid is expressed. The cake of pyroxyline is then taken out of the press, opened out, put into a centrifugal washing machine, and washed with water until clean; then the rotation of the machine is contined, to throw out the surplus water. Or the pyroxyline, after conversion, may be placed in the centrifugal machine, and there deprived of the acids, and, without removal, be thoroughly washed by admitting a copious supply of water, the operation occupying from a few minutes to an hour. When the pyroxyline does not contain more than 5 to 10 per cent. of water, it is dry enough for solution in naphtha, etc.

(5) Instead of evaporating the solvent used in making the celluloid, it may be removed by precipitating the pyroxyline by means of water, mineral naphtha, etc. There is thus obtained a semi-solid mass, containing a small quantity of the solvent, which is passed through grinding rolls or other disintegrating machinery, and then worked up as usual. The celluloid is placed in a vessel containing a revolving agitator or beater, together with water or mineral naphtha in the proportion of 1 lb. of celluloid to 1 qt. of liquid, and the agitator is set in motion. After a short time, the celluloid is let out in a curd-like form, and submitted to pressure (not excessive), to separate the liquid. It is convenient to place it in a vessel of cylindrical form, and about 12 in. in diameter, provided with a movable and perforated bottom, covered with several layers of wire gauze. This is filled with the curd-like celluloid, upon which a plunger is forced down, and a cheese-like block is produced. This is rolled down between rollers heated by steam, and any pigment, etc., is worked in by them at the same time, the mixture being passed through and through till perfected. The solvent used is preferably mineral naphtha, as free from smell as possible. The solvent taken up by the liquid is recovered by distillation, if water has been used; but in the case of naphtha, the greater part will separate on standing, and may then be decanted off.

(6) Camphor is now mostly used as the solvent of the pyroxyline. The latter is first reduced to a fine pulp by grinding it in water in a machine such as is used for grinding paper pulp, and to the pulp thus prepared pulverised camphor is added in the proportion of 1 part by weight of camphor to 2 parts pyroxyline when dry. At the same time is added any desired material for colouring the celluloid or modifying

its specific gravity. The camphor is comminuted by grinding in water, trituration, or solution and precipitation. The camphorated mass is placed in a mould, and heated to a sufficient temperature to liquefy or vaporise the solvent, and is then subjected to heavy pressure. The temperature should never exceed 300° F. (149° C.), or the pulp in contact with the mould will become charred; sometimes 150° F. (66° C.) suffices. The mixture should remain in the mould under heat and pressure till the conversion of the pyroxyline is completed; it is then left to cool under pressure in the mould. When first taken out, it has the consistency of sole leather; but is easily softened by heat till the camphor has evaporated, when it grows as hard as horn.

(7) The following process is adopted in practice to dissolve the pyroxyline in camphor, eliminate the solvent, and form a solid mass of celluloid at one operation. The prepared mixture of soluble pyroxyline and camphor is first dried, by compressing the moist pulpy compound into convenient sized cakes about ¼ in. to ½ in. thick, and arranging them in a pile with intermediate layers of paper, or other absorbent material, and subjecting the pile to pressure in a hydraulic press. By this means, the material is uniformly and sufficiently deprived of its moisture, while the compression of the material and exclusion of the air prevent all danger of ignition when exposed to the sun or the heated air of a drying-room. The mixture of pyroxyline and camphor is subjected to pressure by means of a plunger in a heated cylinder provided with a discharge nozzle or pipe, the cylinder being of sufficient length to cause the conversion of the pyroxyline to take place while the material is being gradually forced through it, so that by replenishing it as it becomes partially empty, a gradual discharge of the celluloid is effected, in the form of a continuous bar or sheet. The cylinder is unequally heated, in such a manner that the mixed material will first be compacted in the colder portion, before the solvent is melted and the process of transformation commences. The air is thus allowed to escape more freely, and is more completely expelled, while the conversion of the pyroxyline is effected in another and hotter portion of the cylinder, as the mass is forced through it. The upper or receiving end of the cylinder is cooled by being surrounded by a cold-water jacket; and the lower or discharging end is heated by a steam or hot-water jacket. The former is supplied by the escape pipe of the hydraulic press. In the discharge end of the converting cylinder is a central heating and distributing case, constructed with radial pins or projections, by which the material, before it escapes from the cylinder, is caused to pass through the annular space around the central core, and in contact with the heated surface of the cylinder, while the spurs or pins divide and mix the material, and at the same time serve to conduct the heat from the cylinder to the central core. The discharge pipe is passed through an equalising warm-water vessel, which keeps it sufficiently warm to prevent the material in contact with the inner surface cooling faster than the central portion, as the unequal cooling, and consequent unequal consistency, of the different portions of the material would cause the central and softer portion to move faster than the outer and harder portion, thus destroying the homogeneity of the mass, and rendering the surface rough and broken. The soluble pyroxyline is first comminuted in a wet condition, and the excess of water is pressed out. The camphor and colours, as required, are then thoroughly incorporated with it by the mixing rollers. The compound, thus prepared, is formed into cakes by means of a mould and follower, the bottom of the mould being made separate, and serving to transform the formed cake to the pile. These cakes are preferably made about 12 in. square and ¼ to ½ in. thick; it would be

difficult to properly absorb the moisture from thicker cakes. These are laid up in a pile with layers of blotting-paper between them, and are then placed in a hydraulic press to remove the water as far as necessary. During this process, the compound is protected from the air, to prevent evaporation of the camphor and to avoid the chance of ignition. The rapidity with which this drying is effected ensures great saving of time and space. The dried material is ready for conversion into celluloid, for which purpose it is transferred, with the solvent, to the converting cylinder. The heat from the steam-jacket surrounding the lower portion of this cylinder brings about the conversion of the pyroxyline to a homogeneous mass of celluloid, which is then forced through a discharge nozzle, constructed according to the desired form of the product, e.g. in bars or sheets, or directly into a mould of the article to be manufactured.

(8) The use of various solvents and combinations of solvent materials has been attempted or proposed ; e.g. a mixture of camphor and oils in about the following proportions, viz.:—

Camphor, camphor oil, or liquid camphor	20 pts. by wt.
Oil, such as castor or linseed, before or after boiling	40 ,, ,,
Pyroxyline (soluble)	40 ,, ,,

These will give a consistency suitable for covering telegraph wires, or for moulding or spreading. For material with greater or less flexibility, or greater or less fluidity, the proportion or character of the oil must be changed. In producing very hard or rigid material, it is preferable to use oils which will themselves harden by exposure to air, as those which have been boiled. Camphor may also be used in about equal proportions with hydrocarbons having a boiling point at 220° to 400° F. (104°-204° C.), or with alcohol or spirits of wine ; or hydrocarbons in equal proportions with alcohol ; or castor-oil in equal proportions with alcohol ; or a distillate of a mixture of camphor-oil and hydrocarbons, or of camphor and bisulphide of carbon in conjunction with alcohol ; or aldehyde, either alone or with alcohol. Either of these solvents may be employed with the other ingredients in about the following proportions to produce a semi-fluid celluloid :—

Pyroxyline (soluble)	27 pts. by wt.
Castor-oil	27 ,, ,,
Camphor	6 ,, ,,
Either of the foregoing solvents	40 ,, ,,

The consistency will depend chiefly on the proportions of the oil, as before.

(9) Parkes suggests the use of a solution of carbon tetrachloride and camphor, either alone or with gums, resins, oils, dyestuffs, etc. He also proposes to use carbon bichloride and camphor, when the solution takes place under the aid of heat and pressure. Camphor, too, is a good solvent when heated to its melting point, at this temperature and under pressure, it dissolves the nitro-cellulose as fast as it can be mixed with the melted camphor, until it forms a stiff mass. This mass, to which other substances may be added, can be rolled and pressed into moulds. To lower the melting-point, he adds oil, paraffin, turpentine, alcohol, benzol, ether, etc., whereby thinner solutions are obtained. Another powerful solvent for nitro-cellulose can be made by conducting sulphurous acid gas through granulated camphor, or by dissolving camphor in sulphurous acid. A solution of camphor in benzol, of such quality that no unpleasant odour is left when the compound is done, works very rapidly with the aid of heat and pressure. Oils, gums, resins, and dyes can be added according to requirements. Turpentine and camphor also dissolve it with heat and pressure very quickly. Nitro-cellulose softens rapidly if sprinkled with alcohol, ether, or other solvents of gun cotton, and then pressed into hot moulds.

Imitation Pearl.—Fish-scales are mixed with the dissolved pyroxyline, and a pearly lustrous material is thus produced. To form a thin veneer of artificial pearl, 1 part of this material is mixed with 100 parts of pyroxyline. The latter is first ground with a solvent and oil to a doughy consistency, the pearly compound is then added, the solvent is separated, and the celluloid is worked up in the ordinary way. But when the celluloid is required in a semi-fluid condition, the solvent must be increased instead of removed, and a much larger proportion of the pearly material will be needed. The best lustre produced is that made in France from the scales of the whiting. In producing a coloured celluloid, preference should always be given to dyes—especially aniline—rather than pigments. The brightest and most delicate colours may be imparted.

To Manufacture Celluloid so as to resemble Ivory.—The following plan is adopted: The celluloid is made without any colouring matter, and is kept as clean and white as possible; when in a dough-like state, it is rolled into sheets $\frac{1}{16}$ in. thick. Meantime another celluloid is prepared containing carbonate of strontia in the proportion of 1 part to about 200 parts of pyroxyline, and this also is rolled into sheets. These sheets are placed alternately one over another, to produce any desired grain. A good plan is to lay a transparent and an opaque sheet one over the other, and roll them up together, then take the roll and twist it, pass it through heated rollers, and roll it down into a slab, for cutting knife handles or whatever may be required.

In working white or light-coloured celluloids, or those in imitation of pearl or ivory, it is necessary that porcelain or glass vessels should be used in its manufacture as far as possible, and the rollers through which it is passed must be covered with platinum, as other metals are acted upon by the celluloid. *A coating of platinum* $\frac{1}{16}$ in. thick will be very durable.

White Celluloid.—For producing a white celluloid, without unduly increasing its specific gravity, the dissolved pyroxyline and other ingredients are mixed with white starch, either from wheat, rice, potatoes, etc., or with arrowroot, tapioca, or other amylaceous substance, or with wheat flour, or with cotton ground and bleached.

Billiard Balls.—The process employed is as follows: To 100 parts of pyroxyline, dissolved, ground, and strained as usual, are added 300 to 500 parts of the solvent—alcohol 100 parts, naphtha 50 parts; 100 to 150 parts of arrowroot or starch; 50 to 200 parts of the best zinc-white. The solid matters are added to the plastic solution of the pyroxyline, and the whole is placed in a closed rolling or grinding apparatus, the rollers being heated by steam, and the compound is ground up till most of the solvent is driven off. The latter is recovered by conveying it through pipes to a Liobig's condenser. The mass is now about as stiff as clay, and may be moulded or rolled, and placed in a warm place for seasoning. When well seasoned, the ball may be turned. When less specific gravity is required, it is best to employ as much amylaceous substances as possible, they being lighter than the zinc. Ground and bleached cotton fibre may be rubbed up with the plastic pyroxyline, in the proportion of 100 parts disintegrated cotton to 300 parts pyroxyline paste. When making coloured celluloid with amylaceous substances or cotton, the colours should be added at the same time, and ground up with the other ingredients.

Dental Celluloid.—The transformation of the pyroxyline is effected by camphor, and without the use of fixed oils or fusible non-solvent gums, which are required to be combined with the material when ether, alcohol, etc., are used, and which would impair the strength, durability, purity, and firmness of texture essential in dental plates. *50 parts at least by weight or* camphor are added to 100 parts of soluble pyroxyline; more camphor makes the compound more plastic. The plates formed are placed in a drying-room heated to 150° to 180° F. (65° to 82° C.), the latter being the maximum, to drive off the camphor. A temperature above 200° F. (93° C.) will expand the material, and make it porous and brittle. It is said that this compound is lighter and stronger than dental vulcanite or indiarubber; its colour is the same as the natural gum, and is unchangeable; it has no unpleasant taste; it is absolutely non-injurious, and never shrinks or warps after setting.

Potatoes as Cellulose.—Considered as raw material for celluloid, potatoes contain about 20 per cent. of starch and 80 per cent. of water. By the action of nitric acid on starch it is converted into a nitro derivative, and this nitro derivative is practically the same as nitro-cellulose, from which celluloid is made. Hence it is possible to make a celluloid from starch; but after taking into account the price of the potatoes and the cost of evaporating off the 80 per cent. of water, it will be found that paper or cotton is a much cheaper raw material.

Colouring Celluloid.—Celluloid is stained during manufacture, but it could no doubt be coloured afterwards if the dye were dissolved in a fluid which would soften the celluloid. Any aniline dye may be dissolved in methylated spirit, and in this the celluloid should be soaked for a short time; if this has not the desired effect add a little camphor to the spirit. In the latter case, do not leave the celluloid in the liquid very long or it will become quite soft.

Hardening and Softening Celluloid.—There is no method of hardening celluloid after it is made; if it is required hard, then 3 to 5 per cent. of resin or shellac is mixed with the original pyroxyline for the manufacture of the celluloid. To soften the celluloid and render it flexible castor oil is used. Opaque celluloid may also be made much harder and more like ivory by the addition of mineral matter such as carbonate of lime or zinc oxide.

Incombustible Celluloid.—Mabille and Lerclerc, patented a process for making a kind of incombustible celluloid. To a solution of celluloid is added a mixture of ether and alcohol containing iron salts. A clear liquid of the consistency of syrup results, and if the solvents are driven off from this, an incombustible non-inflammable celluloid remains. It would appear from the announcement that a chloride of iron is used, since it is stated that should the celluloid become heated the gases of the chlorine components would extinguish the flames.

Incombustible Ivory Substitute.—A compound said to be fireproof, and suitable as a substitute for ivory, is thus made: A solution is prepared of 200 parts of casein in 50 parts of ammonia and 400 of water, or 150 parts of albumen in 400 of water. To the solution the following are added: quicklime, 240 parts; acetate of alumina, 150 parts; alum, 50 parts; sulphate of lime, 1200 parts; oil, 100 parts. The oil is to be mixed in the last. When dark objects are to be made, 75 to 100 parts of tannin are substituted for the acetate of alumina. When the mixture has been well kneaded together and made into a smooth paste, it is passed through rollers to form plates of the desired shape. These are dried and pressed into metallic moulds previously heated, or they may be reduced to a very fine powder, which is introduced into heated moulds and submitted to strong pressure. The objects are afterwards dipped into the following bath: Water, 100 parts; white glue, 1 part; phosphoric acid, 10 parts. Finally, they are dried, polished, and varnished with shellac.

Artificial Ivory.—(1) Make isinglass and brandy into a paste, with powdered egg-shell, very finely ground. Give it any desired colour; oil the mould, into which the paste must be poured warm. Leave the paste in the mould until dry, when its appearance strongly resembles ivory.

(2) In making articles of artificial ivory, the greatest difficulty hitherto has been that in order to gain the necessary firmness, a large percentage of the binding substance had to be used, and hence only dark coloured articles could be produced. Hyatt, however, produced a substance having a pure white colour. This result is arrived at by grinding up any suitable inert matter with a solution of a proper cement. The cement solution is then expressed, the residue is dried and ground, and the powder thus obtained is heated and pressed into moulds. The most suitable inert matter found is oxide of zinc, and the best cement is shellac, or some other similar vegetable substance. A solution of NH_3 forms the solvent: Hyatt first dissolves 8 parts shellac in 32 parts NH_3, sp. gr. 0·995, by thoroughly mixing the two at a temperature of 99° F. (37½° C.) for 5 hours in a rotating cylinder. 40 parts of oxide of zinc are now mixed by hand into the thin syrupy solution, and the mixture is well ground in a colour-mill. The NH_3, having served its purpose, is now driven off by heat, or by exposing the mixture on glass plates for a long time to the air. The residue consisting merely of dry shellac and zinc oxide, is again finely powdered, and the powder thus obtained is pressed into the moulds with a pressure of about 2000 lb. per sq. in., and at a temperature of 275° to 210° F. (125° to 137½° C.). If the article is to be coloured, the colour is added either to the solution just before the first grinding, or the dry mass before the second grinding.

CEMENTS AND LUTES.

(*See also* GLUE ; SEALING WAX ; SHELLAC ; ETC.).

A CEMENT is a natural substance, or a compound which will act as a strong adhesive between either two similar substances, or two substances of quite dissimilar character. Lutes are employed to make tight joints without being adhesive.

The success of a cement depends quite as much upon the manner in which it is used as upon the cement itself. It is especially necessary to understand the characters and properties of the cement. Every cement may be assigned to one of four classes, according as it (1) Dries by evaporation; (2) Congeals by cooling; (3) Hardens by oxidation; or (4) "Sets" by chemical changes. To the first class belong pastes, mucilages, alcoholic and other solutions of gums and resins, and, to a certain extent glue. To the second belong such cements as sealing-wax, turner's cement, shellac, etc. The third class includes gold-size, drying oil, white and red lead, etc.; and the fourth class covers plaster-of-Paris, the so-called iron cement, and others of that kind.

If the best results would be attained, the following rules must be rigorously adhered to:—

1. The cement must be brought into intimate contact with the surface to be united. Thus, when glue is employed, the surface should be made so warm that the melted glue will not be chilled before it has time to effect a thorough adhesion; a drop of melted glue allowed to simply fall on a surface of dry, cold wood and solidify there, will often fail to adhere at all, while if the same drop had been rubbed in, it would have attached itself to it with wonderful power of adhesion. The same is more eminently true in regard to cements that are used in a fused state, such as mixtures of resin,

shellac, and similar materials. These matters will not adhere to any substance unless the latter has been heated to nearly or quite the fusing-point of the cement used. This fact was quite familiar to those who used sealing-wax in the old days of seals. When the seal was used rapidly, so as to become heated, the sealing-wax stuck to it with a firmness that was annoying, so much so that the impression was in general destroyed, from the simple fact that the sealing-wax would rather part in its own substance than at the point of adhesion to the stamp. Sealing-wax, or ordinary electrical cement, is a very good agent for uniting metal to glass or stone, providing the masses to be united are made so hot as to fuse the cement, but if the cement be applied to them while they are cold, it will not stick at all. This fact is well known to the itinerant vendors of cement for uniting earthenware. By heating two pieces of delf so that they will fuse shellac, they are able to smear them with a little of this gum, and join them so that they will break at any other part rather than along the line of union. But although people constantly see the operation performed, and buy liberally of the cement, it will be found that in nine cases out of ten the cement proves worthless in the hands of the purchasers, simply because they do not know how to use it. They are afraid to heat a delicate glass or porcelain vessel to a sufficient degree, and they are apt to use too much of the material, and the result is a failure.

The great obstacles to the absolute contact of any two surfaces are air and dirt. The former is universally present, the latter is due to accident or carelessness. All surfaces are covered with a thin adhering layer of air, which is difficult to remove, and which, although it may at first sight seem improbable, bears to the outer surface of most bodies a relation different from that maintained by the air a few lines away, and until this layer or film of air has been removed, it prevents the absolute contact of any other substance. The reality of the existence of this adhering layer is well known to all who are familiar with electrotype manipulation, and it is also seen in the case of highly polished metals, which may be immersed in water without becoming wet. Thus the surface of a needle retains this film of air so strongly, that it will float on the surface of water rather than give it up.

Unless this adhering layer of air is displaced, it will be impossible for any cement to adhere to the surface to which it is applied, simply because it cannot come into contact with it.

The most efficient agents in displacing this air are heat and pressure. Metals warmed to a point a little above 200° F. (93⅓° C.), become instantly and completely wet when immersed in water. Hence for cements that are used in a fused condition, heat is the most efficient means of bringing them into contact with the surfaces to which they are to be applied.

When it is intended to unite two pieces of earthenware or glass together, or a piece of glass or other substance to metal, by means of a cement that is to be used in a fused state, the surfaces that are to be united should always be made so hot that the cement will become perfectly liquid when brought into contact with them.

In the case of glue, the adhesion is best attained by pressure and friction, combined with moderate warmth. In large establishments, where good glue joints are an important item, a special room, carefully warmed, is set aside for this operation.

2. A very important point is that as little cement as possible should be used. When the united surfaces are separated by a large mass of cement, everything depends upon the strength of the cement itself, and not upon its adhesion to the surfaces which it is used to join; and, in general, cements are comparatively brittle. At first

sight one would suppose that the more cement is used, the stronger will be the joint, and this is an error into which most inexperienced persons fall. Two pieces of earthenware, joined together by a layer of shellac as thin as possible, will adhere together and will be as strong at the junction as at any other part, while the same pieces united by means of a thick layer of the same cement, would fall apart on receiving the slightest jar. The rule which directs us to use as little cement as possible, admits of no exceptions, and as a general thing the only way to obtain thin layers of cements that are to be used in a fused state, is to heat thoroughly the pieces that are to be united, press them forcibly together, and keep them under pressure by means of weights, screws, or cords until the cement has hardened.

3. The third point is the necessity for cleanliness, both in the preparation and in the application of the cements. It may be safely laid down as a positive rule that every extraneous substance that is mixed with the material of a cement is an injury to it. Glue prepared in a greasy pot cannot be expected to make a strong joint, and the presence of dust and dirt tends to weaken *all* cements. So, too, in the application of cements. If it be attempted to glue together two surfaces of wood that are covered with dirt, the substances that are to be united are not wood to wood, but dirt to dirt, and the joint, instead of possessing the strength of wood, united by means of good glue, will have simply the strength of dirt. Moreover, it must be remembered that the different cements do not adhere with equal force to substances of different kinds. Thus, glue adheres powerfully to wood and paper, but not at all to metal or glass. Shellac, if properly applied, adheres readily to earthenware, glass, and metal, but not to some other substances. If, then, glue be applied to a greasy surface, it will not stick. Hence the necessity for great cleanliness. All surfaces should be kept as clean as possible, or, if they should get accidentally soiled, they should be carefully cleaned. The mere rubbing of two wooden surfaces with a dirty hand will weaken the subsequent glue joint by at least 10 per cent.

The most common case in which this rule is violated by the inexperienced is in mending articles which have been formerly glued, and have been again broken at the old place. Such articles when first mended, frequently last for a long time, but when a second attempt is made to glue the pieces together, the joint seems almost to fall to pieces of itself. Here it is attempted to glue together, not two pieces of wood, but two pieces of old glue, and the result is failure. Soak off all the old glue (do not cut or scrape it, or the pieces will no longer fit accurately together), wash the surfaces with a sponge dipped in boiling water, and when they are dry and warm, glue them together in the usual manner, and you will be surprised at the strength of the joint.

4. See that the opposing surfaces make a close, neat joint, before you attempt to cement them. Two pieces of wood that are to be glued together should be planed up so true that they are in contact at every point, and where an article has been broken, the surfaces to be joined should be preserved from being broken or battered. This is particularly the case when articles of glass or earthenware are accidentally broken, and it is not convenient to mend them at the instant. They should be carefully wrapped up in separate pieces of paper, and laid away where they will not be soiled, and where the edges will not be chipped. The joint will be greatly disfigured, and considerably weakened if the edges are chipped and broken by careless handling, or by being needlessly and frequently fitted together. Keep the pieces from contact with each other and with foreign substances until you are ready to join them, and the joint will then be not only strong, but almost invisible.

5. Plenty of time should be allowed for the cement to dry or harden, and this is particularly the case with *oil* cements, such as copal varnish, boiled oil, white lead, etc. These cements are said to *dry*, but they do not dry by evaporation. Instead of losing anything, they actually gain in weight by absorbing oxygen from the air, and this process of oxidation is a very slow one, except as regards the very thin layer that is in immediate contact with the air. Thus when two surfaces, each ½ in. across, are joined by means of a layer of white lead placed between them, 6 months may elapse before the cement in the middle of the joint has become hard. In such cases, a few days or weeks are of no account; at the end of a month, the joint will be weak and easily separated, while at the end of 2 or 3 years it may be so firm that the material will part anywhere else than at the joint. Hence, where the article is to be used immediately, the only safe cements are those which are liquefied by heat and which become hard when cold. A joint made with marine glue is firm an hour after it has been made. Next, in rapidity of hardening, to cements that are liquefied by heat, are those which consist of substances dissolved in water or alcohol. A glue joint sets firmly in 24 hours; a joint made with shellac varnish becomes dry in 2 or 3 days. Oil cements (boiled oil, white lead, red lead, etc.), take months.

6. Where neatness as well as strength is an object, it will often be advisable to use a cement of a colour as nearly like that of the materials to be united as possible. Thus a white porcelain cup, mended with black cement, would show some very ugly lines. If, however, a white cement be used, the lines of fracture will be invisible. The same rule applies to other articles, and it is always easy to colour a cement to any desired tint. (Phin.)

Acid-proof.—(1) A solution of indiarubber in twice its weight of raw linseed-oil, heated, and mixed with an equal weight of pipe clay, yields a plastic mass which will long remain soft under cover, and never completely hardens, so that it may be easily removed at pleasure. It resists most acids, and bears the heat at which sulphuric acid boils. This cement is not at all attacked by hydrochloric, and but very little by nitric acid. When heated it softens but very little. It does not easily dry upon the surface. If this cement is mixed with ⅕ of its weight of litharge, or minium, it dries up in the course of time, and becomes hard. This is known as "Benicke's Cement." (2) Melted indiarubber alone answers well for securing joints against chlorine and some acid vapours. (3) A mixture of China-clay and boiled linseed-oil, in the proportions needed to produce the right consistence. (4) Quicklime and linseed-oil, mixed stiffly together, form a hard cement, resisting both heat and acids. (5) A stiffly mixed paste of pipeclay and coal tar. A cement which, according to Dr. Wagner, is proof against even boiling acids, may be made by a composition of indiarubber, tallow, lime, and red lead. The indiarubber must first be melted by a gentle heat, and then 6 to 8 per cent. by weight of tallow is added to the mixture while it is kept well stirred; next dry slaked lime is applied, until the fluid mass assumes a consistence similar to that of soft paste; lastly, 20 per cent. of red lead is added, in order to make it harden and dry. (7) A concentrated solution of silicate of soda, formed into a paste with powdered glass. This simple mixture will sometimes be found invaluable in the operations of th laboratory where a luting is required to resist the action of acid fumes. (8 1 part rosin, 1 sulphur, 2 brickdust the whole is melted after careful mixing. This lute is proof against th attacks of nitric and hydrochloric aci vapours. (9) A luting which will resist acid vapours and chlorine, even at a high temperature, and is thus applicable to chlorine and hydrochloric apparatus, may be prepared by mixing three parts by weight of fine dry clay with one part by weight of the residue left from the distillation of glycerine. This mixture does not lose its plastic properties even at a high temperature, but is not suited for use where it might be exposed to atmospheric changes, since the glycerine which it contains absorbs moisture. Hence it should be prepared immediately before use.

Alabaster.—Cements for uniting pieces of alabaster, marble, Derbyshire spar, and other kinds of white stone, are in frequent demand. The following recipes give satisfactory results. Those containing resin must be applied hot, and the pieces to be joined must also be heated up to the melting-point of resin. (1) Plaster-of-Paris made to a cream with water. Sets in a few minutes, but it does not become perfectly hard for several days, or until it is thoroughly dry. (2) Yellow resin, 2 parts; melt and stir in one part of plaster-of-Paris, which has been thoroughly dried and heated. (3) Yellow resin, beeswax and plaster-of-Paris, equal parts. (4) Resin, 8 parts; wax, 1; melt and stir in 4 of plaster-of-Paris.

Algerian.—This lute is composed of 2 parts wood ashes, 3 lime, 1 sand, mixed, passed through a sieve, moistened with water and oil, and beaten up with a wooden mallet till the compound has acquired the right consistence.

Almond Paste.—(1) Ground almond cake, from which the oil has been expressed, is mixed up with an equal weight of whiting, and made into a stiff paste with water. It soon becomes very hard and tough. It is much employed for luting stills, retorts, etc., when the heat does not exceed about 320° F. (160° C.); it is capable of resisting the fumes of volatile oils, spirits, weak acids, etc., for some time. (2) Ground almond cake as (1), or linseed cake, is added to starch paste and gum-water.

Amber.—(1) 2 surfaces of amber may be united by smearing them with boiled linseed-oil, pressing them strongly together, and heating them over a clear charcoal fire. To keep the parts in firm contact, it may be well to tie them with the soft iron wire, known as binding wire. (2) A solution of hard copal in pure ether, of the consistency of castor oil, is suggested by Ph. Rust for cementing amber. The carefully cleaned surfaces of fracture, coated with the solution, should be pressed together, and retained in contact by means of a string wound around the object, or in some other suitable way. The operation should be performed as rapidly as possible, since the evaporation of the ether impairs the adhesiveness of the cement; so that all arrangements for compressing the object should be made before laying on the cement. A few days are required for the complete hardening of it. In repairing tubes, as for pipes, any of the solution happening to pass into the interior should be carefully removed at once with a slender feather. (3) The 'Canadian Pharmaceutical Journal' states that amber may be cemented by moistening the surfaces with solution of potash, and pressing them together.

American.—5 parts india-rubber, 3 parts chloroform, 1 part mastic. Is used for cementing glass to any hard surface, or for similar purposes.

Aquarium.—This term has been applied to various waterproof cements which have been used for joining the sides, ends, etc., of tanks for holding water for various purposes. The following are some of the best. (1) Take of finely powdered litharge, fine, white, dry sand, and plaster-of-Paris, each 3 parts, by measure; finely pulverized resin, 1 part. Mix thoroughly and make into a paste with boiled linseed-oil to which dryer has been added. Beat the mixture well, and let it stand 4 or 5 hours before using it. After it has stood for 15 hours, however, it loses its strength. When well made, of good materials, this cement will unite glass and iron so firmly that the glass will often split in its own substance, rather than part from the cement. Glass cemented into its frame with this cement is good for either salt or fresh water. It has been used at the Zoological Gardens, London, with great success. It might be useful for stopping leaks in roofs and other situations. (2) A highly recommended cement is made by melting together, in an iron pan, 2 parts common pitch and 1 part gutta-percha, and stirring them well together until thoroughly incorporated, and then pouring the liquid into cold water. When cold, it is black, solid, and elastic; but it softens with heat, and may be used as a soft paste, or in the liquid state, as is most suitable. It does not harden and crack, and answers an excellent purpose in cementing metal, glass, porcelain, ivory, etc. It may be used instead of putty for glazing windows. (3) Red lead, 3 parts; litharge, 1 part; made into a paste or putty with raw linseed-oil. (4) A cement which gradually hardens to a strong consistence may be made by mixing 20 parts of clean river sand, 2 of litharge, and 1 of quicklime, into a thin putty with linseed-oil. When this cement is applied to mend broken pieces of stone, as steps of stairs, it acquires, after some time, a stony hardness, and unites the parts with great firmness. (5) It is said that a cement of great adhesiveness may be made by mixing 6 parts of powdered graphite with three of slaked lime, 8 of sulphate of baryta, and 7 of linseed-oil varnish. The mixture must be stirred to uniform consistency. (6) ½ lb. best white lead, ground in oil; ½ lb. red-lead, dry; ½ lb. litharge, dry; the two last kneaded into the first. You have now 1½ lb. of the best putty for resisting water. It will soon become hard and continue so. The glass should be bedded in it, and when neatly finished, put away for a fortnight; then varnish with shellac, dissolved in methylated spirits—say 1½ oz. to half a gill—put into a bottle and shaken, will be ready in an hour. It may be coloured, if need be, with a little vermilion. One coat, wherever there is any putty or metal exposed, will be sufficient, and will dry in a few minutes. Your tank will never leak after this if the frame and glass are strong. (7) Mix boiled linseed-oil, litharge, red and white lead together, using white lead in the largest proportion, spread on flannel, and place on the joints. (8) A solution of 8 oz. glue to 1 oz. of Venice turpentine; boil together, agitating all the time, until the mixture becomes as complete as possible; the joints to be cemented to be kept together for 48 hours if required. (9) Take ½ gill of gold size, 2 gills of red-lead, 1½ gill of litharge, and sufficient silver sand to make it a thick paste for use. This mixture sets in about two days. (10) Stockholm tar and red-lead dries quickly and hard, after having been mixed to the consistency of butter. Good for almost anything except where great heat is used. (11) Zinc white 2 parts, copal varnish 1 part. (12) Common resin 8 parts, calcined plaster 1 part. Melt and incorporate. Add boiled oil 1 part. Apply warm. (13) An excellent cement for glass recommended in a German scientific journal is composed of 5 kilo. of hydraulic lime, 0·3 kilo. of tar, 0·3 kilo. of resin, 1 kilo. of horn water (the decoction resulting from boiling horn in water and decanting the latter). The materials are mixed and boiled, and after cooling, the putty is ready for use. This may be used for cementing the cracks in reservoirs or other vessels for holding water, and is said to be equally good for glass, wood, and metal.

Architectural. — Architectural cement is a kind of papier-maché and is used for making entire models, busts, ornaments, etc., rather than for uniting the parts of any article. It is very light, and takes a good polish, but is easily affected by moisture. (1) Reduce paper to a smooth pulp by boiling it in water, and work it over. Squeeze this paste dry, and add an equal bulk of whiting. Then mix the whole into a paste of the required consistence with good size or solution of glue. (2) Same as (1), but with plaster-of-Paris instead of whiting. (3) Strong rice-water size is mixed with paper which has been pulped in boiling water; whiting is then added, in sufficient quantity to produce the desired consistence.

Armenian or Diamond.—(1) The jewellers of Turkey, who are mostly Armenians, have a singular method of ornamenting watch cases, etc., with diamonds and other precious stones, by simply gluing or cementing them on. The stone is set in gold or silver, and the lower part of the metal made flat, or to correspond with that part to which it is to be fixed. It is then warmed gently and the glue applied, which is so very strong that the parts thus cemented never separate. For this glue, which will firmly unite bits of glass and even polished steel, and which may, of course, be applied to a vast variety of useful purposes, a large number of formulæ have been published. The following is the original recipe; Dissolve 5 or 6 bits of gum mastic, each the size of a large pea, in as much alcohol as will suffice to render them liquid; in another vessel dissolve as much isinglass, previously a little softened in water (though none of the water must be used), in good brandy or rum, as will make a 2-oz. phial of very strong glue, adding 2 small bits of galbanum or ammoniacum, which must be rubbed or ground until they are dissolved. Then mix the whole with a sufficient heat, keep the glue in a phial closely stoppered, and when it is to be used, set the phial in boiling water. To avoid the cracking of the phial by exposure to such sudden heat, use a thin, green, glass phial, and hold it in the steam for a few seconds before immersing it in the hot water. (2) *Dr. Ure's.*—Isinglass, 1 oz.; distilled water, 6 oz.; boil to 3 oz., and add rectified spirit, 1½ oz.; boil for a minute or two, strain and add while hot, first, a milky emulsion of ammoniac, ½ oz., and then tincture of mastic, 5 dr. (3) *Keller's.*—Soak ½ oz. of isinglass in 4 oz. water, for 24 hours; evaporate in a water bath to 2 oz., add 2 oz. rectified spirit (alcohol 85 per cent.), and strain through linen. Mix this solution while warm with a solution of best gum mastic in 2 oz. alcohol; add 1 dr. powdered gum ammoniac, and triturate together until perfectly incorporated, avoiding loss of the alcohol by evaporation as much as possible. (4) Isinglass dissolved in alcohol (by first soaking in water), 3 oz.; bottoms of mastic varnish (thick but clear), 1½ oz.; mix well. (5) Fish isinglass dissolved in dilute spirits of wine. Simmer gently in a bottle, with the stopper loosely in it, about one hour. When cold it will be a stiff, almost hard jelly. When required for use it is heated by standing the bottle in hot water. When it gets too stiff spirit can be added to bring it to the right consistency again.

Bottle.—(1) In the better class of preparations, good sealing-wax is used when the object is merely to ornament the cork. Where it is desired to close the pores of cork hermetically a softer and more tenacious cement should be used: *Chemical* or *Glycerine* are good. The following are well-tried recipes for bottle cement or bottle wax. (2) Shellac, 2 lb.; resin, 4 lb.; Venice turpentine, 1½ lb.; red lead, 1½ lb. Fuse the shellac and resin cautiously in a copper pan over the fire; when melted, add the turpentine, and lastly the red lead, which should be dry and warm. Pour into moulds, or make it into sticks by rolling on a marble slab. Care must be taken to have the red lead equally diffused through the melted mass by constant stirring, as owing to its great specific gravity it is apt to sink to the bottom. (3) Resin and beeswax, equal parts; melt together, and add sufficient Venetian red to give a good colour, and enough neat's-foot oil to prevent its being brittle when cold. (4) Sealing-wax, 1 lb.; resin, 1 lb.; beeswax, 8 oz.; melt together. Bottles may be sealed by dipping the corks in this melted mixture. If it froths, add a very small piece of tallow, and stir. (5) Resin, 15 parts; tallow, 4; beeswax, 2; melt, and colour with red ochre or ivory black. (6) Black pitch, 6 lb.; ivory black and whiting, each 1 lb. Melt the pitch and add the other ingredients hot and dry. (7) *Maissiat's*. Indiarubber is melted either with or without about 15 per cent. of either beeswax or tallow; quicklime in fine powder is gradually added, and the heat continued until change of odour shows that combination has taken place, and until a proper consistence is obtained. Used as a waterproof and air-tight covering for corks, bungs, etc. (8) Copal varnish made thick with zinc white, red lead, ivory black or any other colour, and applied like a paint. (9) A paste composed of a commercial silicate of soda and pulverised kaolin, with or without chalk, is applied to the corks, and left to dry. (10) 1 lb. rosin, ¼ lb. tallow or suet, melted together, and sufficient colouring matter stirred in. (11) 5 lb. rosin, 1 lb. beeswax. (12) To 1 lb. of (11) add 3 oz. finely powdered dry whiting, 4 oz. powdered burnt ochre (or sufficient red bole to produce the desired red tint). (13) To 1 lb, of (10) or (11) add sufficient ivory black to produce a black colour. (12) The balsam of Tolu, which has been used for preparing the syrup, has hitherto been utilised only in making a varnish for pills, and it therefore accumulates in course of time to a considerable extent. A composition useful as bottling wax may be prepared by stirring into the melted balsam one-tenth its weight of levigated bole. It sets quickly, with a fine glossy surface, and is less brittle than the wax generally employed. A mixture of residual balsam, amber resin, of each four parts; Venice turpentine, vermilion, of each 1 part; melted together and well stirred, forms sealing-wax of very fair quality.

Brimstone.—Roll sulphur is frequently used alone as a cement for fastening iron bars in holes drilled in stone. The addition of brickdust, sand or resin, lessens its liability to crack. When the yellow colour of brimstone is an objection, a little graphite may be mixed with it.

Brushmaker's.—Take 5 lb. of resin, break it small and melt in a pan. Add 1 quart of resin oil or spirit, and stir until it is a thick gummy consistency. Run into moulds. It is used for securing bristles in wooden stocks, also in binding bristles.

Buckland's.—White sugar, 1 oz.; starch, 3 oz.; gum arabic, 4 oz. These should all be separately reduced to a very fine powder, and then rubbed well together in a dry mortar; then little by little add cold water until the mass is of the thickness of melted glue; put in a wide-mouthed bottle, and cork closely. The dry powder itself, thoroughly ground and mixed, may be kept for any length of time in a wide-mouthed bottle, and when wanted a little may be mixed with water with a stiff brush. It answers ordinarily for all the purposes for which mucilage is used, and as a cement for labels it is specially good, as it does not become brittle and crack off.

Canada Balsam.—(1) This material forms a very useful cement for many purposes. It is the only cement employed by opticians for uniting the lenses of achromatic objectives. For this purpose, it must be pure and colourless. It is easily bleached by exposure to sunlight. If too thick, it may be thinned with benzole. In cementing the two parts of an achromatic lens together, the surfaces should be thoroughly cleaned, and the glasses, having been previously warmed, should be laid on some surface which will not scratch them. By means of a rod of glass or metal, place a drop of balsam on the centre of one lens, and then gently lower the other down upon it. Now apply a slight pressure, and the dark disc in the centre, indicative of optical contact, will rapidly increase in size, until at last the balsam reaches the margin and begins to ooze out at the edges, if the balsam be in excess, as it ought to be. By means of a piece of soft string, if the lenses are large, or a spring clip, if they be small, the lenses should be held firmly together and exposed to a gentle heat in an oven that is cooling, or before a fire until the balsam at the edges has become hard and dry. The string or clip may then be loosened, and all external traces of balsam removed, first by scraping, and afterwards with a little benzole or ether. The above directions, modified to suit circumstances, apply to the cementing of glasses for transparencies or opal pictures ; also to the varnishing of magic-lantern slides, and the protection of any transparent surfaces from the air. (2) Canada balsam forms a very efficient and easily applied cement for the construction of small tanks used by microscopists for keeping minute plants and animals alive in water.

Cap.—Cap cements are so called because they are used for fixing brass caps, stopcocks, etc., on glass apparatus. There are two kinds of cement in use for this purpose ; one consists of resin and other matters, and is fusible by heat, so that it is easily applied, takes very little time to harden, and, if the glass should get broken, or if the brass work requires to be changed, it is very easy to separate the parts by the action of heat. When properly applied, this cement is perfectly air-tight, and is very strong. The only objection to it is that it is easily softened by heat, and therefore cannot be used for apparatus to which heat is to be applied. For air-pumps and other pneumatic apparatus, and similar purposes, it answers perfectly. The other cement consists of white or red lead ground in boiled oil, and applied either to the naked surfaces, or by spreading it on a cloth, which is then placed between the surfaces to be united. The advantage of this kind of cement is that it will stand any heat below 300° F. (149° C.), and that it is steam and air-tight. The objections are that it takes a long time to dry, and that when it has been used to unite pieces of apparatus, it is almost impossible to separate the parts without breaking the glass. This may occasionally be effected, however, either by heating the joint very strongly, or by soaking in solution of caustic potash or soda.

(1) *Faraday's, or Electrical.* Resin, 5 oz. ; beeswax, 1 oz. ; red ochre or Venetian red in powder, 1 oz. Dry the earth thoroughly on a stove at a temperature above 212° F. (100° C.). Melt the wax and resin together, and stir in the powder by degrees. Stir until cold, lest the earthy matter settle to the bottom. Used for fastening brass work to glass tubes, flasks, etc. Faraday's directions for fastening caps to the ends of tubes or retorts are as follows : "One is to be selected of such size as to admit the tube and allow a space for cement about the thickness of a card or a little more, but the cap should never be so small as itself to gripe the glass, or any larger than is necessary to allow room for cement to surround the glass. The cement should be heated to fluidity on the sand-bath but not to a greater degree ; the cap should be warmed over a candle or lamp until it is hot enough to melt cement, and then that part of its interior which is intended to come against the glass, viz. the side of the cylinder, should be covered with the hot cement, applied by a piece of stick. The cap being then laid on its side by the sand-bath to keep it from cooling, the end of the tube or retort is next to be warmed, and a coat of cement applied on the exterior, over every part which is to come into juxtaposition with the cap, but the other parts are not to be unnecessarily soiled ; so much cement is to be left adhering to the glass, that with what there is in the cap, there may be an excess above the quantity that can be retained between the glass and metal when the two are fitted together. When the cap, glass, and cement are all so warm that the latter is fluid or very soft, the cap is to be placed upon the tube, thrust into its right position, receiving a little rotary motion, at the same time to distribute the cement equally over

all parts, and is afterwards to be set aside to cool. When this is well performed, the retort neck or tube should pass along until it is stopped by the inside of the shoulder; no cement should soil its interior or project within the cap, but it should fill every part between the glass and the cap to make a firm, tight junction, and project in a ring from the edge of the cap over the exterior of the glass. The superabundance is easily removed by a knife, and the annular surface left made smooth and tight by a hot wire passed rapidly over it. If a piece of cement, pushed on by the edge of the glass, project in the inside of the cap, it should when nearly cold, be cut off by a knife and removed, so that no loose fragment may remain in the retort or tube."

(2) *Varley's.* Take whiting, dry it thoroughly at a red heat, and reduce it to very fine powder. Melt together 16 parts of black resin, and 1 of beeswax, and stir into the melted mass 16 parts of the dry and warm whiting, which should not be so hot as to affect the resin. (3) *Singer's Electrical.* Resin, 20 parts; beeswax, 4; red ochre, 4; plaster-of-Paris, 1. Dry the powders thoroughly, and add them while warm to the melted resin and wax. (4) A cheaper cement, for lining voltaic troughs, is made of 6 lb. resin, 1 lb. red ochre, ½ lb. plaster-of-Paris, and ¼ lb. linseed-oil. The ochre and plaster should be thoroughly dried and heated, and added to the other ingredients in their melted state. (5) *Temperatures from* 212° *to* 300° *F.* For cementing glass tubes, necks of balloons, etc., into metal mountings, where the apparatus is to be exposed to heat, a mixture of equal parts of red and white lead is preferable to white lead alone. If possible, the surface of the glass should be roughened, and a little tow wrapped round the part where the cement is to be applied. This cement takes some time to acquire its full degree of hardness. In a week it will stand boiling water; in a month it will resist steam at 300° F. (149° C.).

(6) Equal weights red lead and white lead; preferable to white lead alone, and may be depended on for any temperature up to 212° F. (100° C.). (7) A good cement for connecting the parts of electrical or chemical apparatus may be made by mixing 5 lb. resin, 1 lb. wax, 1 lb. red ochre, and 2 oz. plaster-of-Paris, and melting the whole with moderate heat. (8) 7 lb. black resin, 1 lb. red ochre. ½ lb. plaster-of-Paris, well dried, and added while warm; heat the mass to a little above 212° F. (100° C.) and agitate it together, till all frothing ceases and the liquid runs smooth; the vessel is then removed from the fire, and the contents are stirred till sufficiently cool for use. (9) 4 oz. linseed-oil added to the ingredients of (8). (10) *Soulan's.* Make the following solution: Purified resin, 7 dr.; ether, 10 dr.; collodion, 15 dr. Sufficient aniline red. Dissolve the resin in the ether, mix it with the collodion, and colour to taste. All that is necessary to apply the mixture is to dip the cork and the top of the bottle in it, turning it for an instant in the hand while the composition dries. The result is a semi-transparent varnish of pleasing appearance, especially if the cork of the bottle is previously sealed on top with sealing-wax. *See also* GLASS *to* METAL.

Casein.—Casein or cheese has long been used for forming cements, either in combination with quicklime, borax, or, more recently, with silicate of soda. The most important point that requires attention, in order to secure success, is the freeing of the casein from all oily matter. Therefore, when curd is prepared from milk, use only the most carefully skimmed milk, quite free from cream. When cheese is used, select the poorest, and wash it carefully. (1) Skim-milk cheese, cut in slices, and boiled in water. Wash it in cold water, and knead it in warm water several times. Place it warm on a levigating stone, and knead it with quicklime. It will join marble, stone, or earthenware, so that the joining is scarcely to be discovered. (2) Casein, dissolved in soluble silicate of soda or potash, makes a very strong cement for glass or porcelain. Take casein, free from fat, and wash until no longer acid, and silicate of soda solution (waterglass) of each as much as may be needed. Fill a bottle to ¼ of its height with damp casein; then fill the flask with silicate of soda (waterglass), and shake frequently until the casein is dissolved. (3) Take the curd of skim milk (carefully freed from cream or oil), wash it thoroughly, and dissolve it to saturation in cold concentrated solution of borax. This mucilage keeps well, and, as regards adhesive power, far surpasses the mucilage of gum arabic. It forms a valuable preparation for the laboratory, as when spread on strips of bladder it may be used to stop cracks in glass vessels, and will resist considerable heat. (4) Add ½ pint of vinegar to ½ pint skimmed milk; when the curd has settled, pour off the liquid, and wash the curd until free from acid. Add the whites of 5 eggs and beat thoroughly; mix with sufficient finely powdered quicklime to form a paste. This is an excellent cement for mending glass and earthenware. It resists water and a moderate degree of heat. (5) The chief cement used in the island of Sumatra is made from the curd of buffalo milk, prepared in the following way. The milk is left to stand till all the butter has collected at the top. The latter is then removed and the thick sour mass left is termed the curd. This is squeezed into cakes and left to dry, by which it becomes as hard as flint. For use, some is scraped off, mixed with quicklime, and moistened with milk. It holds exceedingly well, even in a hot damp climate, and is admirably adapted for mending porcelain vessels. (6) In the German cantons of Switzerland, a compound of cheese and slaked lime is used, under the name of *käseleim*, for laying floors, puttying joiners' work, making blocks for hand-printing cotton and tapestry goods, and other like purposes. The material sets so rapidly, that it is necessary to mix it as the work goes on, which entails trouble and necessitates a certain knack in its use. A Swiss chemist, Brunnschweiler, of St. Gall, has invented a preparation of lime and skim-milk, to which he gives the name of *Käseleim-pulver*, whereby these inconveniences are avoided. It is a very fine, dry powder, which keeps well, and for use only requires mixing with water, when it displays all the properties of ordinary quicklime. It sets quickly, and hardens with age. Professor Gintl, of Vienna, reports most favourably of the preparation. (7) By heating milk with a little tartaric acid, the casein is coagulated. This casein is then treated with a solution containing six parts of borax, to one hundred parts of water and warmed. It speedily dissolves and forms a very tenacious, durable, and inexpensive adhesive medium.

Celluloid.—A cement for uniting celluloid can be made by dissolving together 1 part of shellac, 1 part spirits of camphor and 3 to 4 parts of 90 per cent. alcohol, all parts by weights.

Chemical.—(1) Melt yellow beeswax with its weight of turpentine, and colour with finely powdered Venetian red. When cold, it has the hardness of soap, but it is easily softened and moulded with the fingers, and for sticking things together temporarily it is invaluable. The consistence of the cement may be varied by changing the proportions of turpentine and wax, and, if a very firm cement is needed, a little resin may be added. (2) Slaked lime is beaten up with white of eggs; strips of linen are soaked in the mixture, and applied immediately, as it dries very rapidly. (3) ¼ lb. pulverised chalk, 1 lb. rye flour, sufficient white of egg; the whole is formed into an almost liquid mass, which is brushed over strips of linen, and the latter are applied to the joints; an additional strip of linen is laid over them, and pressed with a hot iron, which dries the compound.

Chinese, or Schio-liao.—To 3 parts of fresh-beaten blood are added

4 parts of slaked lime and a little alum; a thin, pasty mass is produced, which can be used immediately. Objects which are to be made specially waterproof are painted by the Chinese twice, or at the most three times. Dr. Scherzer saw in Pekin a wooden box which had travelled the tedious road via Siberia to St. Petersburg and back, which was found to be perfectly sound and waterproof. Even baskets made of straw became, by the use of this cement, perfectly serviceable in the transportation of oil. Pasteboard treated therewith receives the appearance and strength of wood. Most of the wooden public buildings of China are painted with schio-liao, which gives them an unpleasant reddish appearance, but adds to their durability. This cement was tried in the Austrian Department of Agriculture, and by the "Vienna Association of Industry," and in both cases the statements of Dr. Scherzer were found to be strictly accurate.

Chinese Glue.—(1) Shellac dissolved in alcohol. Used for joining wood, earthenware, glass, etc. This cement requires considerable time to become thoroughly hard, and even then is not as strong as good glue. Its portability is its only recommendation. (2) A colourless cement, that is recommended highly for joining glass, crockery, stone, wood, leather, etc., is made by covering shellac with strong liquid ammonia, and shaking frequently until dissolved. The solution takes some time to form, and is facilitated by standing, placing the bottle (well stoppered) in a moderately warm situation, and briskly agitating it at intervals. It gives a strong waterproof cement, which adheres to everything. Bleached shellac gives a lighter coloured transparent solution, but the cement will not be so strong. Alcohol or wood spirit may be used in place of the ammonia, but the cement will not be so strong as where ammonia is employed. (3) Clean glass is reduced to very fine powder, and passed through a silken sieve; the powder is ground with white of egg on a stone slab, powdered glass being added till the required consistence is attained. It forms a very firm cement for glass and porcelain, vessels repaired with it breaking in a new place rather than at the joint. (4) 3 oz. shellac, 1 oz. borax, ¾ pint water; the whole is boiled in a covered vessel till dissolved then evaporated to the proper consistence. It dries slowly, but is cheap and useful. Druggists and oilmen often employ it instead of gum, for fixing paper labels to glass or tin, when exposed to damp. (5) Bullock's blood is mixed with ⅕ its weight of quicklime. It will scarcely keep longer than a week when the weather is warm. For use, it is thinned by addition of a little water. It is employed by bookbinders and trunk makers. (6) Finest pale orange shellac, broken small, 4 oz.; rectified spirit (the strongest, 58 o.p.), 3 oz.; digest together in a corked bottle in a warm place until dissolved; it should have the consistence of treacle. For wood, glass, ivory, jewellery, and also fancy works.

Chrome.—This cement consists of a strong solution of gelatine, to which has been added, for every 5 parts of gelatine, 1 of a solution of acid chromate of lime. The mixture becomes insoluble in water under the action of light, in consequence of the partial reduction of the chromic acid, and this property is utilised on several occasions in photography. Professor Schwartz has been experimenting with it as a cement for glass. With a fresh preparation of the solution he covered the surfaces to be united as evenly as possible, pressed them together, and then tied them together. He then exposed the glass to the sun, and at the end of a few hours the operation had perfectly succeeded. Boiling water has no effect on the oxidized cement, and the fracture could scarcely be recognised. Valuable objects in glass, which would be disfigured with common cement, can be satisfactorily repaired in this manner. It is probable that microscopic object-glasses could be better fastened with this than with black asphalt.

Coppersmiths'.—Powdered quicklime mixed with bullocks' blood and applied immediately. Used under the edges and rivets of copper boilers, etc. Cheap and durable.

Corks.—To render corks impervious to air, acids, alkalies and corrosive liquors generally, boil them for some time in melted paraffin. They must be kept under the surface of the melted material, and should be heated and allowed to cool several times, so as to get all the air out of the pores. Corks thus treated cut easily, and make very close joints. For cements for coating cork, *see* BOTTLE.

Crucible.—A mixture of powdered clay and brickdust, made up with water, or a solution of borax. Used to join crucibles which are exposed to a strong heat. When mixed up with borax solution, the lute becomes a compact vitreous mass in the fire. (*And see* FIREPROOF.)

Curd.—(1) Skimmed milk is curdled by the addition of vinegar or rennet, and beaten to a paste with powdered quicklime. (2) ½ pint skimmed milk, ½ pint vinegar, mixed with the whites of 5 eggs; the whole is well beaten, and sufficient quicklime is added to form a paste. These cements are used for mending glass and earthenware; they resist water, and a moderate degree of heat. (*And see* CASEIN.)

Cutlers'.—This is the name given to various kinds of cement used for fastening knives, etc., in their handles. (1) A very firm cement is made of 4 parts resin, 1 of beeswax, into which, when melted, 1 part of fine brickdust is stirred. It adheres with great firmness. (2) Take powdered resin, and mix with it a small quantity of powdered chalk, whiting, or slaked lime. Fill the hole in the handle with the mixture, heat the tang of the knife or fork, and thrust in. When cold, it will be securely fastened. (3) Take 1 lb. resin and 8 oz. sulphur, melt together, form into bars, or when cold reduce to powder; 1 part of the powder is to be mixed with ½ part of iron filings, brickdust or fine sand; fill the cavity of the handle with the mixture, and insert the tang, previously heated. (4) Pitch, 4 parts; resin, 4; tallow, 2; brickdust, 2. Melt the first three ingredients, and add the brickdust hot and finely powdered. (5) Chopped hair, flax, hemp or tow. mixed with powdered resin and applied as above. (6) 16 oz. rosin, 16 oz. hot whiting, 1 oz. wax. (7) 5 parts pitch, 1 wood-ashes, 1 hard tallow, melted together. (8) 4 lb. black rosin melted with 1 lb. beeswax, and 1 lb. red hot whiting added. (9) 16 oz. rosin, 8 oz. sulphur; melt, and when cool reduce to powder. Mix with this some fine sand or brickdust, and use as stated. (10) Take a portion of a quill, put it into the handle, warm the tang, and insert it into the quill in the handle and press it firmly. This is a simple method, and answers the purpose required very well.

Dextrine.—This is prepared from starch by the action of heat, diastase, or acids, and is sometimes called starch gum and British gum. As usually sold, it is a whitish, insipid powder, having a pleasant odour of cucumbers. It is soluble in cold and hot water, and in very dilute alcohol, but it is insoluble in strong alcohol and ether. In France it is largely employed by pastrycooks and confectioners, and by surgeons, as a stiffening for the splints used for fractured limbs. Dextrine is easily prepared for use. It may be mixed with cold water and stirred or beaten for a few moments, when it will dissolve very completely. It may be used immediately, or it may be boiled. This latter improves it. For details of manufacture, see Spons' 'Encyclopædia.'

Diamond.—*See* ARMENIAN.

Earthenware Bisque, cement for.—Burn some oyster shells, reduce to a powder in a muller and pass through a fine sieve. Make this into a paste with white of egg. The shells should be thoroughly cleaned, well-burned, air-slaked and finely powdered, making simply a fine article of lime. The parts joined must be held firmly together for two minutes or so after the cement has been applied. Be sure the parts are thoroughly clean before joining.

Egg.—A number of very cohesive cements, impervious to water and most liquids and vapours for a short time, are made by the union of quicklime with many of the vegetable and animal mucilages and glues. The following is said by Aiken to have been extensively employed by chemists for centuries under the name of "egg cement": (1) Take some white of eggs with as much water, beat them well together, and sprinkle in sufficient slaked lime to make the whole up to the consistence of thin paste. This cement sets or becomes hard very quickly, and must be used at once. It is employed to mend earthenware, china, glass, marble, alabaster, spar ornaments, etc. Although water-proof to a certain extent, it does not resist moisture long unless it has been exposed to heat. (2) Freshly burnt plaster-of-Paris, 5 parts; freshly burnt lime, 1; white of egg, as much as may be needed. Reduce the two first ingredients to a very fine powder, and mix them well; moisten the surfaces to be united with a small quantity of white of egg, to make them adhesive; then mix the powder very rapidly with white of egg, and apply the mixture to the broken surfaces. If they are large, two persons should do this, each applying the cement to one portion. The pieces are then firmly pressed together, and left undisturbed for several days.

Elastic.—*Lenher's.* Indiarubber, 5 parts; chloroform, 3; dissolve and add powdered gum mastic, 1. Elastic and transparent. (2) Cut indiarubber into fine shreds and dissolve together 1 oz. of the rubber, 4 oz. of bisulphide of carbon, 2 dr. isinglass, and ½ oz. gutta-percha; in using this, the parts to be joined must be covered with a thin coat of the solution, and be allowed to dry a few minutes; then heat to melting, place the parts together and compress until cold. (3) Guttapercha, 1 lb.; caoutchouc, 4 oz.; pitch, 2 oz.; shellac, 1 oz.; linseed-oil, 2 oz.; melt together. Must be heated when applied. (*And see* INDIARUBBER *and* MARINE GLUE.)

Engineers'. — (1) Mix ground white-lead with as much finely-powdered red-lead as will make it the consistence of soft putty.

(2) Mix equal parts of white-lead and red-lead, and add as much boiled linseed-oil as is required to give it the proper consistence; or boiled linseed-oil and red-lead mixed into a putty. These compounds are applied by smearing them on a washer of hemp yarn, placed between metallic joints which are to be screwed up. They also answer well for luting the joints between stones, e. g. in cisterns, etc., and dry as hard as stone.

Fat.—(1) Clay is dried, powdered, sifted, placed in an iron mortar, and incorporated with drying oil, added gradually, the whole being well beaten up till the mass assumes the consistence of a fine paste. It should be preserved under a coating of oil, to prevent it drying up. It resists the action of corrosive gases, but inconveniently softens by exposure to heat. (2) Plaster-of-Paris mixed with water, milk, or weak glue. Stands a dull-red heat.

Fireproof.—Cements containing oil, etc., may do to fill cracks, but not to hold two surfaces together. No cement can be depended upon for this purpose to any great extent. For some purposes, the *Glass* cements Nos. 1 and 2 answer very well. (1) Often a lute is required to join the covers to crucibles, or for similar purposes, so as to keep them air-tight when hot. A very valuable composition of the kind is made of glass of borax (fused borax), brickdust and clay, finely powdered together and mixed with a little water when used. No very great nicety is required in the proportions, but about $\frac{1}{10}$ of borax is quite sufficient to bring the earths to that state of semivitrification which is desired. Litharge may be used instead of the borax, but the latter is by far the better, as it promotes that thin spreading fusion which is most efficient. (2) A cement which is said to be useful for stopping cracks in iron vessels which are intended to be strongly heated, is made of 6 parts of clay, 1 of iron filings, and linseed-oil enough for mixture. The oil will, of course, be speedily destroyed, but will leave enough carbonaceous residue to unite the remainder into a firm mass. (3) The following cement is said to be very hard, and to present complete resistance alike to a red heat and boiling water: To 4 or 5 parts of clay, thoroughly dried and pulverised, add 2 of fine iron filings free from oxide, 1 of peroxide of manganese, ½ of common salt, and ½ of borax; mingle thoroughly; render as fine as possible; then reduce to a thick paste with the necessary quantity of water, mixing well. It must be used immediately. After application it should be exposed to warmth, gradually increasing almost to a white heat. (4) A fireproof cement is made from a material found in the Eifel Mountains. Moistened with water, this cement forms an elastic mass, which can be exposed when dry to great heat without shrinking or showing any cracks. Such a cement should be peculiarly adapted for repairing defective fireplaces, cracks in retorts, etc., as mortar for fireproof buildings, and for the interior plastering of furnaces. The mode of its preparation is as follows: the cement is to be well mixed in a dry state, a small quantity of water is added and mixed well together. As a mortar it can be used in the ordinary way. In lining furnaces, however, care must be taken to press the cement well into the walls, so as to leave a smooth, even surface, as when dried by the air the cement easily crumbles and will not harden till ignited. Moreover it must not be treated roughly until it has been well burnt. Cracks in furnaces, retorts, etc., should be well cleansed and scraped, and if possible roughed before applying the cement. The parts to be mended should be damped beforehand. An analysis by Dr. Bischof, of Wiesbaden, gives the following results: The cement is a pale grey, gritty substance, consisting of a good deal of fine dust, with angular and round particles of quartz. When mixed with water it is very sticky, compact, and easily moulded. In 100 parts of the material dried at 248° F. (120° C.) there were:—

Clay earth	10·18
Silica, chemically combined	11·03
Silica, mechanically mixed (sand).	73·58
Iron oxide	0·41
Lime	0·23
Magnesia	0·17
Potassium	0·99
Loss by heat	3·46
	100·05

As will be seen, the quantity of fusible matter, such as iron, etc., is very small indeed, if any. Under the fire treatment the cement showed the following results: After being heated to silver smelting heat, or about 1832° F. (1000° C.), the cement turned to a grey colour, speckled with a few black spots, the fracture being earthy and porous. (Scient. Amer.)

(5) 20 parts fine river sand, 2 litharge, 1 quicklime, sufficient linseed-oil to form a thin paste. Acquires a stony hardness. (6) 2 parts good clay, 8 sharp washed sand, 1 horse-dung; mixed thoroughly, and tempered like mortar. (7) Linseed or almond meal, mixed to a paste with milk, lime-water, or starch-paste; resists a temperature of 500° F. (260° C.). (8) Clay is puddled with water, and to it is added the greatest possible quantity of sand, which has been passed through a hair sieve; the whole is worked up in the hands, and applied in coats more or less thick on vessels needing protection from the direct action of the fire. (9) 1 part of sifted manganese peroxide, 1 pulverised zinc white, sufficient commercial soluble glass to form a thin

paste. To be used immediately. Becomes very hard, and presents a complete resistance to red heat and boiling water. (10) As a coating for glass vessels, to protect them from injury during exposure to fire, pipe-clay and horse-dung are made into a paste with water. This composition is applied by spreading it on paper; it is used by pipe-makers, and will stand the extreme heat of their furnaces for 24 hours without damage. (11) Shredded tow, or plumbago, is substituted for the horse-dung.

Fireproof and Waterproof.—(1) To 4 or 5 parts of clay, thoroughly dried and pulverised, add 2 parts of fine iron filings free from oxide, 1 part of peroxide of manganese, ½ part of sea salt, and ½ part of borax. Mingle these thoroughly and render them as fine as possible, then reduce them to a thick paste with the necessary quantity of water, mixing thoroughly well. It must be used immediately. After application it should be exposed to heat, gradually increasing almost to a white heat. This cement is very hard, and presents complete resistance alike to a red heat and boiling water.

(2) To equal parts of sifted peroxide of manganese and well-pulverised zinc white, add a sufficient quantity of commercial soluble glass to form a thin paste. This mixture, when used immediately, forms a cement quite equal in hardness and resistance to that obtained by the first method. (*See also* ii. 74.)

Fire Lutes.—(1) Mix thoroughly 2 parts good clay, 8 parts sharp washed sand, 1 part horse-dung, then temper like mortar.

(2) Linseed or almond meal mixed to a paste with milk, lime-water, or starch-paste. This lute stands to 500° F.

(3) Mix dry clay in powder with drying oil into a thick paste. The part to which this is applied must be clean and dry.

(4) Plaster of Paris mixed with water, milk, or weak glue. Both (3) and (4) stand a dull red heat.

Flexible cement is made by melting together equal parts gutta-percha and white pine pitch. This cement softens on the water-bath and is not deteriorated by remelting.

French.—Mix thick mucilage of gum arabic with powdered starch or dextrine; a little lemon juice is sometimes added. Used by naturalists in mounting specimens; by artificial flower makers, and by confectioners to stick paper ornaments, wafers, papers, etc., on their fancy cakes.

Glass.—There are several kinds of so-called glass cements, said to be excellent for uniting broken glass, china, etc. (1) Pulverised glass, 10 parts; powdered fluorspar, 20; soluble silicate of soda, 60. Both glass and fluorspar must be in the finest possible condition, which is best done by shaking each, in fine powder, with water, allowing the coarser particles to deposit, and then to pour off the remainder, which holds the finest particles in suspension. The mixture must be made very rapidly, by quick stirring, and when thoroughly mixed must be at once applied. This is said to yield an excellent cement. (2) Red lead, 3 parts; fine white sand, 2; crystallised boracic acid, 3. These ingredients are mixed and fused, and then reduced to a very fine powder, which may be made into a paste with a dilute solution of soluble glass, and applied as an ordinary cement, or it may be mixed with very weak gum water (just enough gum to make it adhesive); after it has been applied, the articles are exposed to a heat sufficient to melt the fusible glass, which is formed by the union of the three ingredients. (3) 2 parts of isinglass are soaked in distilled water until soft; the water is then poured off, and as much alcohol added as will cover the isinglass, and the whole heated until solution takes place; 1 part of mastic is then dissolved in 3 of alcohol; and the two solutions mixed; 1 part of gum ammoniac is then added, the whole well shaken and evaporated in the water-bath until a thick glue-like mass is produced, becoming a stiff jelly on cooling. When required for use, the vessel containing the cement is placed in hot water or in an oven, and the cement applied by means of a brush. It hardens in 24 hours. ('Dingler's Polytech. Jl.') (4) Melt 5 or 6 bits of gum mastic as large as peas in the smallest quantity of alcohol; mix with 2 oz. of a solution of isinglass (made by dissolving isinglass in boiling brandy to saturation), having previously mixed the isinglass solution with 2 or 3 bits of galbanum or gum ammoniac; keep in a well-corked bottle, and gently heat before using. (5) With a small camel-hair brush, rub the edges with a little carriage oil-varnish, and, if neatly put together, the fracture will hardly be perceptible, and, when thoroughly dry, will stand both fire and water. (6) Dissolve fine glue in strong acetic acid to form a thin paste. (7) Canada balsam or clear glue (gelatine), to which has been added a small quantity of bichromate of potash. The latter soon loses its yellow tint, and becomes unaffected by damp when exposed to daylight. (8) 2 parts of common black pitch and 1 part gutta-percha, melted and worked together till mixed; or 2 parts shellac, 1 part Venice turpentine, melted together. These would want using warm. They are both impervious to weather influences. (9) *See* CHROME. (10) Best isinglass, 1 oz.; strong acetic acid, 3 oz.; put in a glass bottle, and dissolve by standing in hot water. Will join glass, china, etc., etc. Make the edges of the pieces to be joined hot, and apply the fluid cement. When cold this cement is solid; it must be made hot for use. (11) Equal parts of wheat-flour, finely-powdered glass, and chalk; add half as much brick-dust, scraped lint, and white of eggs; mix to a proper consistency with water. This will resist heat. (12) To ½-pint of milk put a sufficient quantity of vinegar to curdle it, separate the curd from the whey, and mix the whey with the whites of four eggs, shaking the whole well together. When mixed, add a little quicklime, through a sieve, until it acquires the consistency of a paste. This cement dries quickly, and resists the action of fire and water.

Glass to Metals.—(1) A cement of great adhesive property, particularly serviceable in attaching the brass mountings on glass lamps, as it is unaffected by petroleum, may be prepared by boiling 3 parts of rosin with 1 part of caustic soda, and 5 parts of water, thus making a kind of soap which is mixed with ½ of its weight of plaster-of-Paris. Zinc white, white lead, or precipitated chalk, may be used instead of the plaster, but when they are used the cement will be longer in hardening. (2) A cement for such purposes as fixing metal letters to glass windows consists of copal varnish 15 parts, drying oil 5 parts, turpentine 3 parts, oil of turpentine 2 parts, liquefied marine glue 5 parts. Melt in a water-bath, and add 10 parts dry slaked lime. (3) Brass letters may be securely fastened on glass windows by the following recipe:—

Litharge . . .	2 parts.
White lead . .	1 ,,
Boiled linseed-oil .	3 ,,
Gum copal . .	1 ,,

Mixed just before using, this forms a quick drying and secure cement. (4) 1 lb. of shellac, dissolved in a pint of strong methylated spirit, to which is to be added $\frac{1}{20}$ part of a solution of indiarubber in carbon bisulphide. (5) Take 2 oz. of a thick solution of glue, and mix with 1 oz. of linseed-oil varnish, or ½ oz. of Venice turpentine. Boil together, agitating until the mixture becomes as intimate as possible. The pieces cemented should be fastened together for a space of 48 to 60 hours. (6) One of the best cements for uniting glass to other substances is prepared by putting the best and purest gum arabic into a small quantity of water, and leaving it till next day, when it should be of the consistence of treacle. Calomel (mercurous chloride or subchloride of mercury) is then added in suitable quantity, enough to make a sticky mass being well mixed on a glass plate with a spatula. No more is to be made than that required for immediate use. The cement hardens in a few hours, but it is wiser to leave it for a day or two. To ensure success it is necessary to use only the very best gum; inferior sorts are absolutely useless. (7) Before glass can be soldered to metal, it must be "quicked" upon the side that is to be soldered. The "quicking" process is similar to, if not identical with, the method of silvering looking-glass. When the glass is quicked, it may be readily soldered to the metal, using Venice turpentine or chloride of zinc as a flux. (8) 60 parts starch, 100 finely pulverised chalk, are made into a mixture with equal parts of water and spirit, and the addition of 30 parts Venice turpentine, taking care to agitate the mass with a stick, so as to ensure its homogeneity. (9) 4 parts glue melted with the least possible quantity of water, 1 part Venice turpentine; will resist moisture. (10) That solder in some form adheres to glass is well known and practised by the makers of fictitious jewellery. These are made up of pieces of black glass, cut and polished, and fairly soldered on to metal plates. By breaking one of these across, it will at once be seen how strong the adherence really is. If the work has been well done, the pieces of glass do not fly off, but are difficult to remove except in fragments. This soldering is done as follows: The shields, or metal plates, are coated with a thick layer of tin; these, together with the appropriate pieces of glass, are laid on an iron plate, heated to the melting point of the tin. The piece of hot glass to be soldered is then picked up with forceps, and its edge introduced under the surface of the melted stratum of tin, and slid forward so as to carry some of the metal before it, thus skimming off the oxidised surface so as to bring clean glass and clean metal in absolute contact. No glue must be used; the least trace of oil or resin will spoil the operation. When the piece of glass is fairly in place it is pressed down in order to squeeze out the surplus solder. It is this sliding action that ensures success; if the glass were to be directly pressed down upon the tin solder, no adhesion would take place at all, from the presence of a trace of oxide and the existence of an air film. The glass, of course, must be polished and perfectly clean. (F. H. Wenham.) (11) Wiederhold recommends a fusible metal, composed of 4 parts lead, 2 parts tin, and 2½ parts bismuth, which melts at 212° F. The melted metal is poured into the capsule, the glass pressed into it, and then allowed to cool slowly in a warm place. (12) Cailletet describes a process of soldering glass and porcelain to metal. The glass tube to be soldered is first covered with a thin coating of platinum or silver, by treating it with a film of platinum chloride or silver nitrate, and heating to dull red. A ring of copper is next electro-deposited on the platinised tube, which can then be soldered like any ordinary metallic tube. Solderings effected in this manner are said to be very strong. The top of a tube attached to Cailletet's apparatus for liquefying gases terminates in a soldered end and successfully resists pressure over 300 atmospheres.

Glue. (*See also* GLUE, MANUFACTURE OF.)—(1) Glue is undoubtedly, the most important cement used in the arts. It serves to unite wood, paper, and almost all organic materials. The carpenter, the cabinet maker, the bookbinder, the hatter, and numerous other trades use it extensively, and in some cases to the exclusion of everything else. Good glue, properly prepared and well applied, will unite pieces of wood with a degree of strength which leaves nothing to be desired. The fibres of the hardest and toughest wood will tear asunder before the glued surfaces will separate, and certainly anything more than this would be unnecessary. Bevan found that when two cylinders of dry ash, each 1½ in. diameter, were glued together, and then torn asunder after a lapse of 24 hours, it required a force of 1260 lb. to separate them, and consequently the force of adhesion was equal to 715 lb. per sq. in. From a subsequent experiment on solid glue, he found that its cohesion is equal to 4000 lb. per sq. in. This would indicate that our methods of applying this substance as a cement are capable of improvement and it is undoubtedly true that great care and skill must be used if the best results would be obtained.

Good glue is hard, clear (not necessarily light-coloured, however), and free from bad taste and smell. Glue which is easily dissolved in *cold* water is not strong. Good glue merely swells in cold water, and must be heated to the boiling-point before it will dissolve thoroughly. Good glue requires more water than that which is poor. The best glue, which is clear and red, will require from one-half to more than double the water that is required with poor glue. From careful experiments with dry glue immersed for 24 hours in water at 60° F. (15½° C.), and thereby transformed into a jelly, it was found that the finest ordinary glue, or that made from white bones, absorbs 12 times its weight of water in 24 hours; the glue from dark bones, 9 times, while the ordinary glue made from animal refuse, absorbs but 3 to 5 times its weight of water.

The quality of glue may, to a certain extent, be estimated by breaking a piece. If good, it will break hard and tough, and when broken will be irregular on the broken edge. If poor, it will break comparatively easy, leaving a smooth straight edge.

Glue is insoluble in alcohol, though a small quantity of alcohol may be mixed with the solution without difficulty; but if too much alcohol be used, the glue separates from the water and falls to the bottom of the vessel in the form of a white viscid substance. Neither does it dissolve in ether, or in the fixed or the essential oils, although oily matters of all kinds may be incorporated with the solution of glue, forming a sort of emulsion. These facts will enable readers to judge of the value of those recipes in which they are directed to dissolve glue in alcohol or in oil, for the purpose of making a glue which will remain liquid at all times. A little alcohol may be added, but if the amount of alcohol be sufficient to produce any marked effect, the glue is apt to separate. One of the most marked characteristics of good glue is its property of gelatinizing. By this is meant the fact that a moderately strong solution of glue which is quite fluid when hot, forms a stiff jelly when cold. This property is no bad test of the quality of glue. The firmer the jelly the better the glue. In ignorance of this principle, some persons have made great efforts to get rid of this property, and acids and various salts have been added to the solution of glue for the purpose of preventing its gelatinization, and thus retaining it in a liquid form that would be ready for use at any moment. But by those who have devoted the most careful attention to the subject, the fact stands unquestioned that the strongest glue is that which is purest and which gelatinizes or sets most completely.

Glue being an animal substance, it must be kept sweet, and free from putrefaction; to do this it is necessary to keep it cool after it is once dissolved, and while not in use.

The most serious defects in glue are the mixture of extraneous matters and incipient putrefaction. There are other substances, besides gelatine, present in the matters from which glue is prepared, and unless these substances are carefully separated, the glue will prove of inferior quality. Hence, in selecting glue, choose that which is transparent and free from clouds or flocks in its substance. Very clear and colourless glue is by no means the best; but, whatever be the colour, see that it is clear. It is true that in some cases very finely divided powders have been added to glue with the avowed object of rendering it stronger. Peter Cooper very finely divided Paris white to his glue, and it is claimed that the glue is improved not only in appearance but in actual strength. White lead added to glue is said to make it waterproof as well as to strengthen it, and from the well-known relation of white lead to oils and animal substances it is not impossible that this may be the case.

Glue which exhibits a bad odour when moistened should be rejected and used only for making size, and for uniting the coarser varieties of articles; and when the glue-pot begins to exhibit any signs of putrefaction, it ought to be carefully cleaned out and thoroughly soaked and washed, for the presence of a little bad glue will soon destroy a whole batch of a good article.

To Prevent the Cracking of Glue.—When articles that have been glued are exposed to great heat, they are often much damaged by the cracking of the glue. This evil may be avoided by adding to the glue chloride of lime, which is a very soluble salt, and prevents the glue from drying so as to become brittle. Glue so prepared adheres firmly to glass, metal, etc., and may be used for sticking on tickets so as not to come off. (Pharm. Zeitch. of Russia.)

Quick Drying Glue.—Put your glue into a bottle ⅔ full, and fill up with common whisky; cork tight and set by for 2 or 3 days, and it will dissolve without the application of heat, and will keep for years.

Fish Glue.—(1) A correspondent of a technological paper describes a method of preparing glue from fish scales. He says: "The natives of the Maldive and Laccadive Islands, and the Malays of the coasts of Borneo and Sumatra, have a glue which they make as follows: They take the scales of a kind of fish, called by English and American sailors salt-water trout (identical with the salt-water trout of the Gulf of Mexico), and after thoroughly washing them in a glazed earthen jar, which they stopper tightly, and weight so that it will remain under water, they put this jar in a pot of water, and boil it until the scales are reduced to a semi-transparent viscous mass. This requires several hours. Care should be taken that no water or extraneous matter, fluid or solid, be allowed to get into the jar with the scales. The glue thus made is the most tenacious, and at the same time the most transparent and beautiful that I have ever seen. I have made it in this country from the scales of perch, trout, and bass. I am informed that a similar glue is made from the bladders of various fishes." (2) The bows of the Laplanders are composed of two pieces of wood, glued together. One of them is of birch, which is flexible, and the other of the fir of the marshes, which is stiff, in order that the bow when bent may not break, and when unbent it may not bend. When these two pieces are bent, all the points of contact endeavour to disunite themselves, and to prevent this the Laplanders employ the following cement: They take the skins of the largest perches, and having dried them so that the greasy part may be removed by scraping and wiping, and the oil soaked out by any porous material, they soak them in water until they are so soft that they may be freed from the scales, which are thrown away. They then put 4 or 5 of these skins in a reindeer's bladder, or they wrap them up in the soft bark of the birch tree, in such a manner that water cannot touch them, and place them thus covered in a pot of boiling water with a stone above them to keep them at the bottom. When they have boiled about an hour, they take them from the bladder or bark, and they are then found to be soft or viscous, like strong glue. In this state they employ them for gluing together the two pieces of their bows, which they strongly compress together and tie up until the glue is well dried. These pieces never afterward separate.

Liquid Glue. — Various attempts have, as already stated, been made, with the intention of retaining the glue in a liquid form, and of thus avoiding the inconvenience attending the use of a cement which requires to be liquefied by heat whenever it is to be used. The addition of a little nitric acid will prevent the glue from gelatinizing or becoming solid, and the same effect is produced by the addition of a little vinegar, or of pyroligneous acid, which will also prevent it from moulding. It is supposed that the latter is substantially the formula for making the well-known Spaulding's glue. The addition of these substances injures the glue, however. Spaulding's glue may be more convenient than common glue, but it is far inferior to it in strength. More recently it has been proposed to add sulphate or chloride of zinc to common glue for the purpose of keeping it liquid. A solution of shellac in alcohol has been used and highly extolled as a substitute for common glue. It forms a tolerable liquid cement, but is far inferior to glue. Any of the following recipes will afford a liquid glue which will answer well enough for purposes where no great strength is required; but there is no cement which is more convenient than common glue, and yet which will unite wood with anything like the efficiency of that article.

(1) Dumoulin's. This is one of the oldest forms and one of the best; it is prepared as follows: Soak 8 oz. of best glue in ½ pint of water in a wide-mouthed bottle and melt by heating the bottle in a water-bath. Then add slowly 2½ oz. of nitric acid, sp. gr. 1·330, stirring constantly. Effervescence takes place under escape of nitrous acid gas. When all the acid has been added, the liquid is allowed to cool. Keep it well corked, and it will be ready for use at any moment. It does not gelatinize, nor putrefy, nor ferment. It is applicable to many domestic uses, such as mending china, wood, etc. (2) A very strong glue may be made by dissolving 4 oz. of glue in 16 oz. of strong acetic acid by the aid of heat. It is semi-solid at ordinary temperatures, but needs only to be warmed, by placing the vessel containing it in hot water for a short time, to be ready for use. (3) Dilute officinal phosphoric acid with 2 parts, by weight, of water, and saturate with carbonate of ammonia; dilute the resulting liquid, which must be still somewhat acid, with another part of distilled water, warm it on a water-bath, and dissolve in it enough good glue to form a thick, syrupy liquid. It must be kept in well-closed bottles. (4) Spaulding's. This is simply good glue prepared with strong vinegar instead of water. Dilute, rectified pyroligneous acid, which is a coarse form of vinegar, containing a very little creosote, may be used. It prevents mould and fermentation. (5) Glue water and vinegar, of each 2 parts. Dissolve in a water-bath, and add alcohol, 1 part. (6) A solution of shellac in alcohol is often sold under the name of "liquid glue." *See* CHINESE GLUE. (7) Macerate 6 parts glue in 16 of water, until the glue is swollen and soft. Add 1 of hydrochloric acid, and 1½ sulphate of zinc, and let the mixture be kept for 10 or 12 hours at a temperature of 154° to 158° F. (68° to 70° C.). Answers admirably for attaching labels to tin and to glass when exposed to damp. (8) The writer of the following claims to have a personal knowledge of its excellence: "An excellent liquid glue is made by dissolving glue in nitric ether. The ether will only dissolve a certain amount of the glue: consequently, the solution cannot be made too thick. The glue thus made is about the consistency of molasses, and is doubly as tenacious as that made with hot water. If a few bits of indiarubber, cut into scraps the size of a buck-shot, be added and the solution allowed to stand a few days, being stirred frequently, it will be all the better, and will resist dampness twice as well as glue made with water." (9) Puscher states that a clear liquid glue may be obtained by

dissolving 1 part of sugar in warm water, adding ¼ part of slaked lime, and keeping at 145°-165° F. for several days, with shaking at intervals. From 4 to 5 parts of the resulting solution of sugar-lime are then used to dissolve 1 part of glue, the whole being gently warmed. The addition of 2 to 3 per cent. of glycerine improves the glue, and a few drops of lavender oil remove the peculiar odour. (10) Ordinary glue, 100 oz., is dissolved in a water-bath with 250 oz. vinegar; when the whole has become liquid, 250 oz. ordinary alcohol, and 10 oz. alum are added, the mass being kept over a fire for a quarter of an hour. It is very tenacious, and does not become putrid. When too thick, a little water may be added, and the mixture may be heated. It is very useful for cementing, in the cold, a variety of small objects, and is much employed by the makers of false pearls. (11) 100 parts of ordinary gelatine are dissolved in 400 parts of water containing 6 to 7 parts of oxalic acid. The solution is kept for 5 or 6 hours on the water-bath in a porcelain infusion pot, after which it is neutralised with carbonate of calcium, the insoluble precipitate filtered off, and the clear filtrate evaporated at a moderate temperature, until about 200 parts are obtained. The product is a durable, slightly tinted but clear liquid glue.

Lip or Portable Glue.—(1) Soak 4 oz. best glue and 1 oz. isinglass in water until soft. Pour off the superfluous water, and add 1 oz. brown sugar. Melt the whole together with a gentle heat, and allow it to evaporate until quite thick. Pour into a flat-bottomed dish that is quite cold; if placed on ice, so much the better, as it will prevent the glue sticking to it. When solid, cut into cakes. (2) Glue, 5 oz.; sugar, 1 oz.; dissolved in water, boiled down, poured into moulds, or on to a slab of slate or marble, and dried. (3) Isinglass and parchment glue, each 1 oz.; sugar candy and gum tragacanth, each 2 dr.; add to them 1 oz. of water; boil the whole till the mixture appears, when cold, of the consistence of glue. Then form it into small rolls for use. This glue, wetted with the tongue and rubbed on the edges of the paper, silk, etc., to be cemented, will, on their being laid together and suffered to dry, unite them as firmly as any other part of the surface. (4) Put a pinch of shredded gelatine into a wide-mouthed bottle; put on it a very little water, and about ¼ of glacial acetic acid; insert a well-fitting cork. If the right quantity of water and acid be used, the gelatine will swell up into worm-like pieces, quite elastic, but at the same time, firm enough to be handled comfortably. The acid will make the preparation keep indefinitely. When required for use, take a small fragment of the swelled gelatine, and warm the end of it in the flame of a match or candle; it will immediately "run" into a fine clear glue, which can be applied at once direct to the article to be mended. The thing is done in half a minute, and is, moreover, done well, for the gelatine so treated makes the very best and finest glue that can be had. This plan might be modified by dissolving a trace of chrome-alum in the water used for moistening the gelatine, in which case, no doubt, the glue would become insoluble when set. (5) Take ½ lb. of very best Scotch glue, melt it in a clean glue-pot. When quite dissolved, pour off the clear part into another glue-pot, add ½ pint boiling water, well mix. Then add 2 oz. best moist sugar; well mix the whole together, at the same time keeping it quite hot. It may then be cast into moulds, or poured gently on a marble or stone, or slab. When nearly set, cut into strips for use. It should be kept in boxes with a little powdered sugar or starch. This glue will be found both cheap and effective. It is much stronger than paste or gum.

Damp and Moisture Resisting Glue.—(1) Take of the best and strongest glue enough to make a pint when melted. Soak this until soft. Pour off the water as in ordinary glue making and add a little water if the glue is likely to be too thick. When melted, add 3 tablespoonfuls of boiled linseed-oil. Stir frequently and keep up the heat until the oil disappears, which may take the whole day and perhaps more. If necessary add water to make up for that lost by evaporation. When no more oil is seen, a tablespoonful of whiting is added and thoroughly incorporated with the glue. (2) A glue which is proof against moisture may be made by dissolving 16 oz. of glue in 3 pints of skim milk. If a stronger glue is wanted, add powdered lime.

Glycerine.—Chemists and others know well the difficulty of keeping very volatile liquids. Bottles of ether for example, are shipped for India, and when they arrive are found to be more than half empty. The chemist sometimes puts a bottle of benzole or bisulphide of carbon on his shelves, and when he next requires it, he finds the bottle empty and dry. The usual remedy for this is a luting of melted sulphur, which is difficult to apply and hard to remove. Glycerine cement, however, is easily prepared and applied, and is said to prevent the escape of the most volatile liquids. It is merely painted around the cork or stopper. It quickly dries, and becomes extremely hard, but can be easily scraped off with a knife when it is necessary to open the bottle. (1) The hardest cement is produced by triturating 50 grm. of litharge with 5 c.c. of glycerine. If more glycerine is used, the mass hardens much more slowly and imperfectly (2) A cement which rapidly hardens and still has considerable firmness is obtained by adding 2 volumes of water to 5 of glycerine (sp. gr. 1·240) 6 c.c. of this liquid are incorporated with 50 grm. of litharge.

(3) *Pollack's.* Litharge and red lead, equal parts: mix thoroughly, and make into a paste with concentrated glycerine to the consistence of soft putty. This cement takes some time to dry, but it turns almost as hard as stone, and resists moisture and heat very well. Pollack used it to fasten the different portions of a fly-wheel with great success; while when placed between stones and once hardened, it is easier to break the stone than the joint.

Elastic Glue.—Dissolve glue by the aid of a water bath, evaporate till a thick fluid is obtained, add an equal weight of glycerine, continue the evaporation with stirring until the remaining water is driven off; run it out on a marble slab to cool. This composition might be advantageously applied to the manufacture of printers' rollers, and similar articles.

Granite.—Clean river sand, say, litharge 1 lb., quicklime ½ lb., and linseed-oil sufficient to form a thin paste. Becomes exceeding hard and strong after a short time.

Gum Arabic.—Gum arabic is the product of various species of *Acacia.* It is the material from which true mucilage is made, and it forms one of the most valuable cements. Faraday says there is no cement which exceeds it in strength. Pure gum arabic is in roundish or irregular pieces of various sizes, more or less transparent, hard, brittle, and breaking with a shining fracture. It is usually white or yellowish white, but frequently presents various shades of red, and is sometimes of a deep orange or brownish colour. In powder it is always more or less purely white. It is liable to adulteration both in powder and in masses. Much of the white gum arabic of the shops, consists of the cheaper and coarser gum Senegal, bleached by what is called "Picciotto's process." The gum is dissolved in water, and sulphurous acid gas passed through the solution. The liquid is afterwards boiled to expel the sulphurous acid, a little of which, however, still remains behind. The product is very white, but lacks the peculiar toughness and adhesiveness of the best gum.

The powdered gum is frequently adulterated with dextrine, gum Senegal, starch, sugar, cherry-tree gum, etc. These substances are not difficult of detection, but where a good article is required for preparing a cement, it is best to purchase gum arabic in lump from a reliable dealer, taking care, in any case, to avoid the bleached article. Powdered gum has no advantage, except in the fact that it dissolves more quickly than when in lumps. It, therefore, forms, when in this state, a very convenient and portable cement, which may be made ready in an instant by the addition of a little water.

For preparing gummed surfaces which will adhere when moistened (such as gummed labels, etc.), there is no material superior to gum arabic. The great difficulty with gum arabic, and, indeed, with other gums and pastes, lies in the fact that when *thoroughly* dry, they become brittle, so that the label or other object falls off. A simple remedy for this difficulty lies in the addition of 5 to 10 drops of glycerine to each fl. oz. of mucilage or paste. Gum arabic is used not only alone, but when mixed with other matters. The following formulæ produce very good cements. (1) Rub together, in a mortar, 2 parts nitrate of lime, 25 of water, and 20 of powdered gum arabic. This forms a transparent cement of great strength, and applicable to wood, porcelain, glass, and stone. The surfaces to be united should be painted with the cement, and firmly bound together until the drying is complete. (2) A white paste, adhesive to most surfaces, is said to be made as follows: A solution of 2½ oz. gum arabic in 2 qt. of warm water, is thickened with flour paste well boiled, and to this is added a solution of alum and sugar of lead, 720 gr. each, in water; the mixture is heated and stirred till about to boil, and then cooled. It may be thinned, if neccessary, with the gum solution. It will be seen that this mucilage consists of a solution of gum arabic and flour paste in acetate of alumina, coloured white with sulphate of lead. (3) To 250 grm. (9 oz.) of mucilage prepared by dissolving 2 parts of gum in 5 of water, add 2 grm. (30 gr.) of crystallised sulphate of aluminium dissolved in the least possible quantity of water. A solution of alum does not answer as well as the simple sulphate of alumina, which can be prepared from alum by precipitating the alumina with ammonia, washing thoroughly on a filter, and dissolving in sulphuric acid. The mucilage thus prepared does not sour or mould, and may be used as a cement for general purposes. (4) It is said that a mixture of 1 part dry chloride of calcium, or 2 parts of the same salt in the crystallised form, and 36 parts gum arabic, dissolved in water to a proper consistency, forms a mucilage which holds well, does not crack by drying, and yet does not attract sufficient moisture from the air to become wet in damp weather.

Preserving Gum-Arabic Solutions.—A few drops of oil of cloves, or of alcohol, or any essential oil, will preserve a quart of the mucilage of gum arabic or gum tragacanth from turning sour.

Mucilage for Labels.—Macerate 5 parts of good glue in 20 parts of water for 24 hours, adding 20 parts of rock candy, and 3 parts of gum arabic.

Artificial or British Gum.—Malt, crushed small, 1 lb.; warm water, 2 gal. Mix; heat the whole to 145° F.; add of potato starch 5 lb.; raise the heat to 160° F., and mash for about 25 minutes, or until the liquid becomes thin and clear; it must then be instantly run off, and raised to the boiling point to prevent the formation of sugar; after boiling for 3 or 4 minutes, the whole must be filtered and evaporated to dryness by a steam heat.

Gum Tragacanth.—(1) Known amongst mechanics as gum dragon and gum drag. It comes in irregular-shaped fragments, varying in size from that of a small pea to a hazel nut or larger. It is yellowish-white, and sometimes translucent like horn. It is hard and tough, and very difficult to reduce to powder unless when exposed to a freezing temperature, or when thoroughly dried and ground in a heated mill or mortar. When so treated, however, it is possible to produce a very fine white powder. When thrown into water, it absorbs that liquid, and swells up and forms a paste which is largely used by manufacturers of lozenges, as it gives great toughness to the mass of sugar and other ingredients. If sufficient water be used, and the soft mass be heated or mixed up, it forms a uniform, soft, adhesive paste. If allowed to settle, however, part of the gum separates from the water, and is deposited. Boiling water dissolves the gum more perfectly at first, but even when so treated, it separates afterwards. According to Planche, a mixture of gum tragacanth and gum arabic forms, with water, a thinner mucilage than the same quantity of either of these gums alone. (2) Equal parts of tragacanth powder and powdered gum arabic, moistened, according to requirements at the time, with dilute acetic acid, or, if the colour will not be of any importance, with ordinary vinegar. This forms a very strong mucilage which keeps well.

Hensler's. — Litharge, 3 parts; quicklime, 2; white bole, 1; grind up with boiled linseed-oil. Forms a very tenacious and hard cement, but one that takes a long time to dry. It is used for china, glass, etc.

Hot-water Pipe Joints.—(*See* PIPE JOINTS, STEAM AND HOT-WATER.)

Iron. — Iron filings or borings, when mixed with sulphur, sal-ammoniac, etc., expand and form a compact mass which makes a very firm steam-tight joint if properly applied. Concerning this cement, Dr. Ure says: The iron rust cement is made of 50 to 100 parts of iron borings, pounded and sifted, mixed with 1 part of sal-ammoniac, and when it is to be applied, moistened with as much water as will give it a pasty consistence. Formerly, flowers of sulphur were used, and much more sal-ammoniac in making this cement, but with decided disadvantage, as the union is effected by oxidation, and the consequent expansion and solidification of the iron powder, and any heterogeneous matter obstructs the effect. The best proportion of sal-ammoniac is 1 per cent. of the iron borings. (2) Mix 4 parts of fine borings or filings of iron, 2 of potter's clay, and 1 of powdered firebrick, and make them into a paste with salt and water. When this cement is allowed to concrete slowly on iron joints, it becomes very hard. (3) Coarsely powdered iron borings, 5 lb.; powdered sal-ammoniac, 2 oz.; sulphur, 1 oz.; and water sufficient to moisten it. This composition hardens rapidly; but if time can be allowed, it sets more firmly without the sulphur. It must be used as soon as mixed, and rammed tightly into the joints. (4) Sal-ammoniac, 2 oz.; sublimed sulphur, 1 oz.; cast-iron filings or fine turnings, 1 lb. Mix in a mortar and keep the powder dry. When it is to be used, mix it with 20 times its weight of clean iron turnings or filings, and grind the whole in a mortar; then wet it with water until it becomes of convenient consistence, when it is to be applied to the joint. After a time it becomes as hard and strong as any part of the metal. (5) The following is said to form a very hard cement: Take a few spoonfuls of iron filings, and oxide of iron in the form of black scales which fall from red-hot bars of iron in blacksmiths' shops; crush them fine with a hammer, mingle with the powder an equal bulk of the best Portland cement, and render the mass plastic by adding the white of eggs, and work for a few minutes, until the plastic material is about of the consistence of soft putty. Only a small quantity should be prepared at once, as it will set in a short time. (6) A correspondent of the 'English Mechanic' says that he has used the following recipe with the greatest success for the cementing of iron railing tops, iron gratings to stoves, etc., and with such effect as to resist the blows of the sledge hammer: Take equal parts of sulphur and white lead, with about a sixth of borax; incorporate them so as to form one homogeneous mass. When going to apply it, wet it with strong sulphuric acid, and place a thin layer of it between the two pieces of iron, which should then be pressed together. In 5 days it will be perfectly dry, all traces of the cement having vanished, and the iron will have the appearance of having been welded together. (7) 5 parts sulphur, 2 of graphite, and 2 of fine iron filings are melted together, taking care that the sulphur does not catch fire. The parts previously warmed, are covered with the cement, reduced to a pasty consistence on a fire, and firmly pressed together. This cement, it is said, is very well adapted to fill out leaks in cast-iron vessels. (8) For Hot-Air Pipes. 60 parts (by measure) of chalk, 20 of limestone or lime, 20 of salt, 10 of loamy sand, 5 iron filings, and 5 of red or blue clay, properly mixed together, triturated, and calcined. (9) For Hot-Water Cistern. To 4 or 5 parts clay dried and pulverised, add 2 of fine iron filings free from oxide, 1 of peroxide of manganese, ½ of sea-salt, and ½ of borax. Thoroughly incorporate these in as fine a state as possible, reduce them to a thick paste with water, and use immediately. It should then be exposed to a heat, gradually increasing to almost a white heat. This cement resists heat and boiling water. (10) Glycerine and litharge, stirred to a paste, harden rapidly, and make a tolerable cement for iron upon iron, for two stone surfaces, and especially for fastening iron in stone. This cement is insoluble, and is not acted upon by strong acids. (11) You can cement cloth to polished iron shafts by first giving them a coat of best white-lead paint; this being dried hard, coat with best Russian glue, dissolved in water containing a little vinegar or acetic acid. (12) For Iron and Glass. Copal varnish 15 parts, drying oil 5, turpentine 3, oil of turpentine 2, liquefied glue 5; to be all melted in a water-bath, and add 10 parts of slaked lime. (13) For cast-iron cisterns of large dimensions: composed of sal-ammoniac, clean borings, and urine, mixed one day before required. The proportions are 1 lb. of sal-ammoniac to 100 lb. borings, with sufficient urine to make a stiff paste—to be well driven into the joints with a caulking tool a little narrower than the space between the flanges. Give at least 3 days to set before filling cistern with water. The cement sets as hard as the metal itself. (14) For iron pots and pans. 2 parts sulphur, 1 of graphite; the sulphur is held in an old iron pan over the fire till it begins to melt; the graphite is then added, and the mass well stirred till thoroughly melted and combined; then poured out on an iron plate or smooth stone, and broken up when cold. Used like solder with a soldering-iron. Holes should first be filled with a rivet and then cemented over.

(15) A permanent and durable joint can, it is said, be made between rough, cast-iron surfaces by the use of asbestos with sufficient mixed white lead to make a very stiff putty. This will resist any amount of heat, and is unaffected by steam or water. It has been used for mending or closing cracks in cast-iron retorts that were used for the distillation of oil and gas from cannel coal. The heat being applied to the bottom of retorts, and the temperature of iron maintained at a bright red heat, after a time the bottom of the retort would crack, the larger portion of the crack being downward towards the fire. The method employed was to prepare the mixture, and place on top a brick, then place the brick on a bar of iron or shovel and press the cement upward to fill the crack in the iron, holding it for some time until it had penetrated the cavity, and somewhat set. Of course, during this operation, the cap was removed from the retort, so that no pressure of gas or oil forced the cement outward until set. (16) Stir into 1 part of sweet oil and 1 part of molasses, 1 part each of barytes, Venetian red, litharge, and red lead, and 1½ part each of plumbago, Paris white, and yellow ochre. It takes several hours to prepare, but will remain plastic for years.

Impervious.—Zinc white, rubbed

up with copal varnish to fill up the indentures in corks; when dry, to be covered with the same mass, somewhat thinner; and lastly, with copal varnish alone.

Indianite.—(*a*) 100 parts finely-chopped rubber, 15 rosin, 10 shellac, dissolved in a sufficient quantity of bisulphide of carbon. Used for uniting pieces of rubber.

(*b*) Rubber, 15 gr.; chloroform, 2 oz.; mastic, ½ oz. The two first-named to be mixed, and after the rubber is dissolved add the mastic in powder; allow to macerate for a week.

Indiarubber.—(1) Pieces of indiarubber may be readily united by means of the pasty mass obtained by acting upon pure rubber by its appropriate solvents. These are: Sulphuric ether, coal-tar naphtha, bisulphide of carbon, caoutchoucin, benzine, and oil of turpentine. But as it is difficult to dissolve rubber satisfactorily on a small scale, and as the cement may be bought ready made at a cheap rate, it is hardly worth while to enlarge upon its preparation. Those who wish to try it will probably succeed best by cutting pure rubber (not that which has been vulcanised) into very thin slices, boiling it in water so as to soften and expand it, and then digesting it in hot coal-tar naphtha, or oil of turpentine. Several days are required to effect the solution. When this cement is used for uniting pieces of rubber, the surfaces which are to be joined must be fresh; the surfaces should therefore be either pared with a knife or rasped with a file. They may then be coated with the cement, pressed firmly together, and exposed to a gentle heat for a few days. (2) For mending indiarubber shoes, boots, and apparatus where the regular rubber cement cannot be obtained, the following directions have been given: Cut 2 lb. indiarubber into thin, small slices; put them in a vessel of tinned sheet-iron, and pour over 12 to 14 lb. of bisulphide of carbon. For the promotion of solution, place the vessel in another containing water previously heated up to about 86° F. (30° C.). The solution will take place promptly, but the fluid will thicken very soon, and thus render the application difficult, if not impossible. In order to prevent this thickening, a solution of indiarubber and resin in spirits of turpentine must be added to the solution of indiarubber in bisulphide of carbon, and in such quantity that the mixture attains the consistency of a thin paste. The solution of indiarubber and resin in spirit of turpentine should be prepared as follows: Cut 1 lb. of indiarubber into thin, small slices; heat in a suitable vessel over a moderate coal fire, until the indiarubber becomes fluid; then add ½ lb. powdered resin and melt both materials at a moderate heat. When these materials are perfectly fluid, then gradually add 3 or 4 lb. spirit of turpentine in small portions, and stir well. By the addition of the last solution, the rapid thickening and hardening of the compound will be prevented, and a mixture obtained which fully answers the purpose of gluing together rubber surfaces, etc. (3) It is said that a good cement, that will render indiarubber in any form adherent to glass or metal, may be made as follows: Some shellac is pulverised, and then softened in 10 times its weight of strong ammonia, whereby a transparent mass is obtained, which becomes fluid after keeping some little time, without the use of hot water. In 3 or 4 weeks the mixture is perfectly liquid, and, when applied, it will be found to soften the rubber. The rubber hardens as soon as the ammonia has evaporated again, and thus becomes impervious to both gas and liquids. For cementing the rubber sheet, or the material in any shape, to metal, glass, and other such surfaces, this cement is strongly recommended. (4) Virgin or native indiarubber is cut with a wet knife into the thinnest possible slices, which are then divided by shears into threads as fine as small twine. A small quantity of the shreds (say $\frac{1}{10}$ of the capacity of the bottle) is then put into a wide-mouthed bottle, and the latter is three-fourths filled with benzine of good quality, and perfectly free from oil. The rubber almost immediately commences to swell, and in a few days, if often shaken, it will assume the consistence of honey. Should it be inclined to remain in undissolved lumps, more benzine must be added. Thinness may be corrected by adding more indiarubber. A piece of solid rubber no larger than a walnut will make a pint of the cement. It dries in a few minutes, and, by using 3 coats in the usual manner, leather straps, patches, rubber soles, backs of books, etc., may be joined with great firmness. (5) Indiarubber, 8 gr.; chloroform, 600 gr.; mastic resin, 150 gr. The indiarubber is dissolved in the chloroform, the mastic is added, and the whole is left to macerate for 8 days, that being the time necessary for the solution of the mastic. The cement is applied cold on a brush, and is used for joining glass. (6) Very finely-divided indiarubber is melted at a temperature of 392° F. (200° C.). As soon as fusion commences, $\frac{1}{15}$ the quantity of tallow or wax is added, taking care to watch the heat and to stir without ceasing. When the mass is completely melted, lime, slaked and sifted, is added in small instalments, till it amounts to half the quantity of the indiarubber. The cement thus obtained is soft; if the proportion of lime be doubled, the cement will be harder, but still supple. When the compound has acquired a suitable consistence, the fire is withdrawn, and the preparation is finished. This forms a good cement for hermetically sealing vessels. It does not dry, and remains for a long time ductile and tenacious; but it may be made to harden if necessary, by adding 1 part of red lead to the quantities indicated. (7) For Vulcanised Rubber. Oil and sulphur: 1 of sulphur to 12 of oil gives a substance like treacle; 4 to 12 of oil a stiff substance like rubber. To be successful in making this compound, take an iron ladle, such as is used for the melting of lead, and fill it not more than $\frac{1}{3}$ full, and place it over a clear fire. Owing to a quantity of water being held in the oil by the vegetable matter, it will begin to seethe, and, if not closely watched, boil over into the fire. After a little time it will subside, the surface remaining quite placid, with now and then little flickers of smoke flitting across the surface. Your sulphur must be either roll brimstone or the crude sublimed, i.e. not washed or treated with acid. If the first, finely powder it, and mix by degrees in the oil, stirring all the time until incorporated. (8) Guttapercha. To make guttapercha cement, melt together in an iron pan 2 parts of common pitch and 1 of guttapercha; stir them well together until thoroughly incorporated, and then pour the liquid into cold water. When cold it is black, solid, and elastic; but it softens with heat, and at 100° F. (38° C.) is a thin fluid. It may be used as a soft paste, or in a liquid state, and answers an excellent purpose in cementing metal, glass, porcelain, ivory, etc. It may be used instead of putty in glazing windows.

Rubber and Guttapercha.—(1) In making a cement one should know pretty thoroughly what is to be expected of it before they could advise upon it. For instance, an ordinary rubber cement will hold on a host of different surfaces and with the best of success, except where there is continued dampness. For holding to damp walls, or surfaces where there is a constant pressure of moisture there is nothing equal to Jeffrey's marine glue, the formula for which has been published and republished all over the world. It consists of—1 part rubber, 12 parts coal tar, and 2 parts asphaltum. The rubber, after having been massed, is dissolved in the undistilled coal tar, and the asphaltum is then added. This glue, as its name indicates, is oftentimes used for mending articles at sea, or patches, for instance, that are to be laid on surfaces that are to be under water, and it has been found to be a most excellent thing.

(2) A guttapercha cement for leather is obtained by mixing the following. It is used hot. Guttapercha, 100 parts; black pitch or asphaltum, 100 parts; oil of turpentine, 15 parts.

(3) An elastic guttapercha cement especially useful for attaching the soles of boots and shoes, as on account of its great elasticity it is not liable to break or crack when bent. To make it adhere tightly, the surface of the leather is slightly roughened. It is prepared by dissolving 10 parts guttapercha in 100 of benzine. The clear solution from this is then poured into another bottle containing 100 parts linseed oil varnish, and well shaken together.

(4) Davy's universal cement is made by melting 4 parts common pitch with 4 of guttapercha in an iron vessel, and mixing well. It must be kept fluid, under water, or in a dry, hard state.

(5) A very adhesive cement, especially adapted for leather driving belts, is made by taking bisulphide of carbon 10 parts, oil of turpentine 1 part, and dissolving in this sufficient guttapercha to form a paste. The manner of using this cement is to remove any grease that may be present on the leather by placing on the leather a piece of rag and then rubbing it over with a hot iron. The rag thus absorbs the grease, and the two pieces are then roughened and the cement lightly spread on. The two pieces are then joined, and subjected till dry to a slight pressure.

(6) A solution of guttapercha for shoemakers is made by taking pieces of waste guttapercha, first prepared by soaking in boiling water till soft. It is then cut into small pieces, placed in a vessel, covered with coal tar oil, tightly corked to prevent evaporation, and allowed to stand for 24 hours. It is next melted by standing in hot water till perfectly fluid, and well stirred. Before using it must be warmed as before, by standing in hot water.

(7) A cement for uniting rubber is composed as follows: 100 parts finely chopped rubber, 15 of resin, 10 of shellac; these are dissolved in bisulphide of carbon.

(8) Another rubber cement is made of 15 gr. rubber, 2 oz. chloroform, 4 dr. mastic; first mix the rubber and chloroform together, and when dissolved the mastic is added in powder. It is then allowed to stand by for a week or two before using.

(9) An elastic cement is made by mixing together and allowing to dissolve the following: 4 oz. bisulphide of carbon, 1 oz. fine rubber, 2 dr. isinglass, ½ oz. guttapercha. This cement is used for cementing leather and rubber, and when to be used the leather is roughened and a thin coat of the cement is applied. It is allowed to completely dry, when the two surfaces to be joined are warmed and then placed together and allowed to dry.

(10) Cement used for repairing holes in rubber boots and shoes is made of the following solution: (1) Caoutchouc 10 parts, chloroform 280 parts. This is simply prepared by allowing the caoutchouc to dissolve in the chloroform. (2) Caoutchouc 10 parts, resin 4 parts, gum turpentine 40 parts. For this solution the caoutchouc is shaved into small pieces and melted up with the resin, the turpentine is then added, and all is then dissolved in the oil of turpentine. The two solutions are then mixed together. To repair the shoe with this cement, first wash the hole over with it, then a piece of linen dipped in it is placed over it; as soon as the linen adheres to the sole, the cement is applied as thickly as required. ('Chem. Trade Jl.')

Rubber to metal.—For cementing rubber or gutta-percha to metal, Morits Grossman, gives the following receipt: Pulverised shellac, dissolved in ten times its weight of pure ammonia. In three days the mixture will be of the required consistency.

The ammonia penetrates the rubber and enables the shellac to take a firm hold, but as it all evaporates in time, the rubber is immovably fastened to the metal, and neither gas nor water will remove it.

Isinglass.—This is probably the purest form of gelatine or animal glue, and it makes one of the strongest cements known. As a cement, it may be treated like glue. From the fact that it is made from the sounds of fishes, it is sometimes called fish-glue.

Ivory, or Mother-of-Pearl.—The American or Diamond cement unites pieces of ivory with great firmness, but where a white cement, of nearly the same colour as ivory is required, the following modification will be found useful: (1) Dissolve 1 part of isinglass and 2 of white glue in 30 of water; strain and evaporate to 6 parts, then add $\frac{1}{30}$ part of gum mastic, dissolved in $\frac{1}{2}$ part of alcohol, and add 1 part of zinc white. When required for use, warm and shake well. The broken edges to be joined must also be warmed.

Japanese.—This is simply a paste made of fine rice flour, well boiled and ground in a mortar.

Jet.—Shellac is the only cement used by jewellers for jet articles. The broken edges should be made warm before applying the cement. Should the joint be in sight, by smoking the shellac before applying it, it will be rendered the same colour as the jet itself.

Jewellers' (*and see* ARMENIAN).—It sometimes happens that jewellers, in setting precious stones, break off pieces by accident; in this case they unite the parts so that the joint cannot be easily seen, with gum mastic, the stone being previously made hot enough to melt it. By the same medium, cameos of white enamel or coloured glass are often joined to a real stone as a ground, to produce the appearance of an onyx. Mastic is likewise used to cement false backs or doublets to stones, to alter their hue. Ure. (1) Shellac, melted and run into sticks as large as quills. Used for joining glass, earthenware, etc.; the edges are heated sufficiently to melt the cement, which is then applied, and the joint is made while the heat lasts. (2) Tears of gum mastic employed in the same way. (3) Shellac, 2 parts; Venice turpentine, 1 part; fused together and formed into sticks. Used as the preceding.

Labels.—(1) The usual adhesive coating for "gum tickets," is the cheaper varieties of gum arabic dissolved in water, applied with a brush and dried. (2) Mix dextrine with water, and add a drop or two of glycerine. (3) Labels that are exposed to acid fumes or damp, may be attached with any good paste, and when dry, coated with copal varnish. If neatly done, the appearance is very good, and moisture and acids have no action on them. (4) For attaching labels to tin and other bright metallic surfaces, first rub the surface with a mixture of muriatic acid and alcohol; then apply the label with a very thin coating of the paste, and it will adhere almost as well as on glass. (5) To make cement for attaching labels to metals, take 10 parts tragacanth mucilage, 10 of honey, and 1 of flour. The flour appears to hasten the drying, and renders it less susceptible to damp. (6) Another cement that will resist the damp still better, but will not adhere if the surface is greasy, is made by boiling together 2 parts of shellac, 1 of borax, and 16 of water. (7) Flour paste to which a certain proportion of nitric acid has been added, and heat applied, makes a lasting cement, but the acid often acts upon the metals. The acid converts some of the starch into dextrine. (8) Dissolve 2 dr. isinglass in 4 oz. distilled vinegar; add as much gum arabic as will give it the required consistency. This mucilage keeps very well, but is apt to become thinner, when a little more gum may be added. (9) Dissolve isinglass in vinegar to a pretty thick consistence when warm. This congeals on cooling, and before it is used should be gently warmed. (10) A capital adhesive liquid for sticking tickets on glass, wood, or paper, is obtained as follows: About ½ oz. fine glue which has been a day before soaked in water, and some candy sugar, with ½ oz. gum arabic, and 3 oz. water, are placed in a small bowl over a spirit lamp, and continually stirred till the composition thoroughly boils and dissolves, and the mass becomes thin. When coated with this cement and then dried, the tickets, when moistened with the tongue, will stick with the greatest tenacity. (11) Dextrine, 2 parts; acetic acid, 1; water, 5; dissolve in a water-bath and add 1 part of alcohol. Forms an excellent mucilage for stamps and labels that are to be kept ready gummed. (12) It is said that for the labels of seltzer or soda water bottles, the best paste is one made of good rye flour and glue, to which linseed-oil varnish and turpentine have been added in the proportion of ½ oz. of each to the lb. The paste must be made quite hot, and the oil incorporated with it by thorough heating. Labels attached by this cement do not fall off in damp cellars. (13) Soften good glue in water; then boil it with strong vinegar, and thicken the liquid, during boiling, with fine wheat-flour, so that a paste results. (14) Starch-paste, with which a little Venice turpentine has been incorporated while it was warm. (15) Paint solution of tannin over the spot, let dry, and then affix the label previously gummed and moistened. (16) Corrosive sublimate, 125 parts; wheaten flour, 1000 parts; absinthe, 500 parts; tansy, 500 parts; water, 15,000 parts. This cement is useful for vessels which are kept in a damp place; the addition of the sublimate retards the destruction of the labels. (17) Starch, 100 parts; strong glue, 50 parts; turpentine, 50 parts; the whole boiled in water. This cement dries quickly. (18) Best red sealing-wax ½ oz., spirits of wine 2 dr., and from 5 to 10 drops of muriate of tin; let stand for 36 hours, and stir with a glass rod before using. This answers for making nearly everything adhere to tin articles. (19) Leather to polished zinc. Nothing better than glue, made in the ordinary manner, but rather thin, to which is added its own bulk of Beaufoy's acetic acid. (20) T. A. Richardson, the architect, recommends to every 2 tablespoonfuls of the best wheaten flour to add a teaspoonful of common moist or brown sugar, and a little corrosive sublimate; the whole to be boiled, and continually stirred to prevent getting lumpy, till of the right thickness. To stop mouldiness, a few drops of some essential oil, as lavender or peppermint. This paste is used to make different thicknesses of cardboard. In putting or jointing together, he recommends 6 oz. gum arabic (best), 1 oz. or less of moist or lump sugar, 1 teaspoonful of lavender or other essential oil, and a tablespoonful of gin—the whole to be mixed in cold water to the consistency of a thick syrup, no heat being in any way applied. (21) Dissolve 180 gr. of best French glue in 180 gr. of water by soaking and heating. Then add a solution of 1 gr. of shellac in 6 gr. of alcohol, and stir well as long as the solution is warm. Mix also 35 gr. of dextrine in 50 gr. of alcohol and 25 gr. of water, stir it well in a beaker and place it into warm water until the solution is completed and has acquired a clear brown colour. Mix this solution with that of the glue, and pour the whole into a suitable form in which it may solidify. When wanted for use, cut off a small piece and liquefy it by warming.

Labels.—(22) Lehner publishes the following formula for making a liquid paste or glue from starch and acid: Place 5 lb. of potato starch in 6 lb. (3 quarts) of water, and add ½ lb. of pure nitric acid. Keep it in a warm place, stirring frequently for 48 hours. Then boil the mixture until it forms a thick and translucent substance. Dilute with water, if necessary, and filter through a thick cloth. At the same time, another paste is made from sugar and gum arabic. Dissolve 5 lb. gum arabic and 1 lb. sugar in 5 lb. of water, and add 1 oz.

of nitric acid and heat to boiling. Then mix the above with the starch paste. The resultant paste is liquid, does not mould, and dries on paper with a gloss. It is useful for labels, wrappers, and fine bookbinders' use. (23) Paper pasted, gummed, or glued on metal, especially if it has a bright surface, usually comes off on the slightest provocation, leaving the adhesive material on the back of the paper, with a surface bright and slippery as ice. The cheaper description of clock dials are printed on paper and then stuck on zinc; but for years the difficulty was to get the paper and the metal to adhere. It is, however, said to be now overcome by dipping the metal into a strong and hot solution of washing soda, afterwards rubbing perfectly dry with a clean rag. Onion juice is then applied to the surface of the metal, and the label pasted and fixed in the ordinary way. It is said to be almost impossible to separate paper and metal thus joined. (24) Dissolve 1 oz. gum tragacanth and 4 oz. gum arabic in 1 pint water; strain, and add 14 gr. thymol suspended in 4 oz. glycerine; finally add water to make 2 pints. This makes a thin paste suitable for labelling bottles, wooden or tin boxes, or for any other purpose paste is ordinarily called for. It makes a good excipient for pill-masses, and does nicely for emulsions. The very small percentage of thymol present is not of any consequence. This paste will keep sweet indefinitely, the thymol preventing fermentation. It will separate on standing, but a single shake will mix it sufficiently for use. (25) 4 oz. rye flour, ½ oz. powdered gum acacia. Rub to a smooth paste with 8 oz. of cold water, strain through a cheese cloth, and pour into 1 pint of boiling water. Continue the heat until thickened to suit. When nearly cold add :—

1 oz. glycerine, 20 drops oil cloves.

This is suitable for tin or wooden boxes or bottles, and keeps sweet for a long time. (26) 4 oz. rye flour, 1 pint water, 1 dr. nitric acid, 10 minims carbolic acid, 10 minims oil cloves, 1 oz. glycerine. Mix the flour with the water, strain through a cheese cloth, and add nitric acid. Apply heat until thickened to suit, and add other ingredients when cooling. This is suitable for bottles, tin or wooden boxes, and will not spoil. (27) 8 parts dextrine, 2 parts acetic acid, 2 parts alcohol, 10 parts water. Mix dextrine, water, and acetic acid to a smooth paste, then add the alcohol. This makes a thin paste, and is well suited for labelling bottles and wooden boxes but is not suitable for tin boxes.

Laboratory.—Equal parts of pitch, rosin, and plaster-of-Paris united by fusion. Used for lining casks for holding chloride of lime, and for joining and coating the masonry of acid chambers, etc.

Lamps.—The cement commonly used for fastening the tops on petroleum lamps is plaster-of-Paris, which is porous, quickly penetrated by the petroleum, and soon destroyed. Another cement which has not this defect is made by boiling 3 parts of resin and 1 of caustic soda in 5 of water. This composition forms a soap, which, when mixed with half its weight of plaster-of-Paris, sets firmly in about ¾ hour. It is said to be of great adhesive power, not permeable by petroleum, a low conductor of heat, and but superficially attacked by hot water. Zinc white, white lead or precipitated chalk may be used instead of the plaster, but when they are used the cement will be longer in hardening.

Lead.—(1) Simply pure white lead ground in oil, and used very thick, is an excellent cement for mending broken crockery ware; but it takes a very long time to harden sufficiently. The best plan is to place the mended object in some store-room, and not to look after it for several weeks, or even months. After that time it will be found so firmly united that, if ever again broken, it will not part on the line of the former fracture. It resists moisture, and a heat not exceeding that of boiling water. (2) White lead, ground in oil, a sufficient quantity; add dry red lead, enough to make a stiff putty. Put the mass in a mortar or on a block of iron or smooth stone, and pound it till it becomes soft; continue to add red lead, and pound until the mass will no longer become softer by pounding, nor stick to the fingers. At this time it should be of sufficient tenacity to stretch out 3 or 4 in. when pulled, without parting. The more protracted the pounding, the softer, finer, and more tenacious the cement becomes. Interpose this putty between the flanges of steam-pipe joints, taking care to put a thin grummet of packing or wicking around the diameter of the bore, to keep the cement from squeezing through when the flanges are screwed together. It is indestructible by steam or water, and makes the best joint known to the engineer. (3) Mix 2 parts finely powdered litharge with 1 of very fine sand, and 1 of quicklime which has been allowed to slake spontaneously by exposure to the air. This mixture may be kept for any length of time without injuring. In using it, a portion is mixed into paste with linseed-oil, or, still better, boiled linseed-oil. In this state it must be quickly applied, as it soon becomes hard. (4) Mohr's. Equal parts litharge and brickdust made into a paste with linseed-oil, applied, and a little sand dusted over. (5) Serbat's. Sulphate of lead calcined and ground, 72 parts; peroxide of manganese, 24 parts; linseed-oil, 13 parts; intimately mixed. This lute is soft, and will remain in that state indefinitely. For use, it only needs to be rubbed up between the hands. It may be advantageously employed in boilers, steam engines, etc.; it sets perfectly, and does not soften under the influence of heat, but, on the contrary, becomes very hard, especially if care be taken to pass a hot iron over the joints. A sudden leak may be stopped immediately, by applying some of this lute under a hot iron. It is preferable to red lead.

Leather.—(1) Common glue and isinglass, equal parts, soaked for 10 hours in just enough water to cover them. Bring gradually to a boiling heat, and add pure tannin until the whole becomes ropy, or appears like the white of eggs. Buff off the surfaces to be joined, apply this cement warm, and clamp firmly. (2) Mix 10 parts bisulphide of carbon with 1 of oil of turpentine, and then add enough guttapercha to make a tough thickly-flowing liquid. One essential pre-requisite to a thorough union of the parts consists in freedom of the surfaces to be joined from grease. This may be attained by laying a cloth upon them and applying a hot iron for a time. The cement is then applied to both pieces, the surfaces brought into contact, and pressure applied until the joint is dry. (3) Another leather cement is made of guttapercha dissolved in bisulphide of carbon, the mixture being about the thickness of syrup; the parts to be cemented must be well coated, so as to fill the pores of the leather; then heat the cement and join the ends, hammering the parts until the cement is cold. (4) To cement leather to metal: Wash the metal with hot gelatine; steep the leather in an infusion of nut galls (hot), and bring the two together. (5) 1 lb. guttapercha, 4 oz. indiarubber, 2 oz. pitch, 1 oz. shellac, 2 oz. linseed-oil; melted together; it hardens by keeping, and needs remelting for use. (6) Leather to metal: (*a*) melt together equal parts asphalt and guttapercha, and apply hot under a press. (*b*) F. Sieburger recommends the following process by Fuchs. Digest 1 part crushed nutgalls with 8 distilled water for 6 hours, and strain; macerate glue with its own weight of water for 24 hours, and dissolve; spread the warm infusion of the galls on the leather, and the glue on the roughened metallic surface; apply the prepared surfaces together, and dry gently; the leather then adheres so firmly to the metal that it cannot be removed without tearing. ('Polyt. Notizblatt.') (7) Leather to Pasteboard. Strong glue, 50 parts, is dissolved with a little turpentine in a sufficiency of water, over a gentle fire; to the mixture is added a thick paste made with 100 parts of starch. It is applied cold, and dries rapidly. (8) A good cement for splicing leather for straps is gutta-percha dissolved in bisulphide of carbon, until it is of the thickness of treacle; the parts to be cemented must first be well thinned down, then pour a small quantity of the cement on both ends, spreading it well so as to fill the pores of the leather, warm the parts over a fire for about half a minute, apply them quickly together, and hammer well. The bottle containing the cement should be tightly corked and kept in a cool place.

Letters, Cements for Fastening. *Metal Letters upon Glass, Marble, Wood, etc.*—(1) Mix copal varnish, 15 parts; boiled linseed-oil, 5; oil of turpentine, 5; and glue, 5. The glue is dissolved by placing the mixture in a water bath. When solution is complete, 10 parts of slaked lime are added. (2) Mix 15 parts of a varnish prepared from sandarac and white resin with 5 parts of linseed-oil, boiled with litharge, and 5 parts of oil of turpentine. To this add 5 parts of marine glue, and after dissolving this mixture on a water bath add 10 parts of flake white and white-lead. (3) Mix 15 parts of copal varnish prepared with an addition of resin and 5 parts of oil of turpentine with 2 parts of powdered isinglass, 5 of sifted iron filings and 10 of washed clay or ochre. (4) Mix 15 parts of copal varnish prepared with gum lac, 5 of linseed-oil boiled with litharge, 8 of solution of caoutchouc in tar oil, 7 of tar oil with 10 of Roman cement and plaster of Paris. (5) Brass letters may be securely fastened on glass panes with a cement composed of, litharge 2 parts, white lead 1, boiled linseed-oil 3, gum copal 1. Mix just before using. It forms a quickly drying and secure cement.

Porcelain Letters.—Mix 80 parts of starch and 100 of pulverised chalk with equal parts of water and alcohol, together with the addition of 30 parts of Venetian turpentine. Care must be had to agitate the mass with a stick so as to insure its homogeneity.

London.—Boil a piece of Gloucester cheese three times in water, each time allowing the water to evaporate. Take the paste thus left and thoroughly incorporate with dry quicklime. It will mend glass, wood, china, etc., very effectually. (*And see* CASEIN.)

Mahogany.—The following lutes are used to stop holes and cracks in mahogany furniture: (1) Beeswax, 4 oz.; melt and add Indian red, 1 oz., and enough yellow ochre to produce the required tint. (2) Shellac melted and coloured as above, very hard.

Marble.—(1) *Keene's.* Baked gypsum or plaster-of-Paris, steeped in a saturated solution of alum, and then recalcined and reduced to powder. For use it is mixed up with water as ordinary plaster-of-Paris. This preparation forms a stucco, rather than a cement. It takes a high polish, and when coloured is very beautiful, but does not unite pieces as strongly as: (2) An excellent cement for mending marble or any kind of stone, is made by mixing 20 parts of litharge and 1 of freshly burned lime in fine dry powder. This is made into a putty by linseed-oil. It sets in a few hours, having the appearance of light stone. (3) Resin, 8 parts; wax, 1; plaster-of-Paris, 4; mix by fusion. The pieces to be joined must be made hot. (4) Lac coloured to imitate the marble; may be mixed with marble dust passed through a silken sieve. (5) W. F. Reid gives the following. Begin with the raw gypsum in lumps of moderate size, burning them at the usual temperature (below red heat). The solution of alum should contain 1 part of this salt in 10 of water. There is no difficulty in dissolving this quantity if the water be previously heated and the alum coarsely pulverised. By immersing the lumps of burnt gypsum in this solution while they are still warm, and leaving them in it for about 15 minutes, they will become thoroughly saturated with the liquid. They should then be allowed to drain and again burnt, but this time at a red heat. Gypsum which has been treated in this way, forms, when pulverised, a slow-setting cement which ultimately attains great hardness, and has *frequently been used for making paving tiles, especially in Italy.* (6) *Into a solution of chloride of zinc, sp. gr. 1·490 to 1·652, is* introduced, 3 per cent. of borax or sal ammoniac; when this is dissolved, oxide of zinc, which has been subjected to a red heat, is added, till the mass attains the desired consistence. This cement becomes as hard as marble, and may be used for moulding. (7) 12 parts Portland cement, 6 slaked lime, 6 fine sand, 1 infusorial earth, and mix into a thick paste with silicate of soda. The object to be cemented need not be warmed. The cement sets in 24 hours, and the fracture can then hardly be detected. The cemented portions are harder than the rest, and the fracture cannot by any chance be reopened. ('Polytech. Centralblatt.')

Marine Glue (and *see* Indiarubber).—Marine glue is probably the strongest cement known, and when well made and properly applied, it is capable of uniting wood, metal, glass, leather, etc., with a strength and durability that is astonishing. It is a combination of shellac and indiarubber in proportions which vary according to the purposes for which the cement is to be used. Some is very hard, some quite soft. The degree of softness is also regulated by the proportion of naphtha used for dissolving the indiarubber and shellac. It is difficult to prepare it on the small scale. The following is the formula for the ordinary variety: (1) Indiarubber (cut small), 1 part; coal-tar naphtha, 12; digest in a covered vessel with heat and agitation, and when the solution is complete, add of powdered shellac, 20 parts. Continue the heat and stirring until perfect liquefaction has taken place, and pour the fused mass, whilst still hot, on slabs of polished metal or stone so as to form thin sheets. When used it is to be heated to its melting-point, 248° to 250° F. (120° to 121° C.), in an iron vessel, and applied in the liquid state with a brush. Great care and considerable experience are necessary to enable any *one to use this cement. If the solid cement be heated but a very few degrees above its melting-point, it crumbles and becomes useless.* One may succeed by cutting it in shreds, placing these between the parts to be joined, and heating the whole until the glue can be pressed into uniform contact with the entire surfaces. Sometimes it is convenient to use a form of the glue which is more fluid, from containing more naphtha. The following formulæ answer in such cases, but are not as strong as the ordinary marine glue. (2) Dissolve 3 parts shellac, and 1 of indiarubber, in separate vessels, in ether free from alcohol, applying a gentle heat. When thoroughly dissolved, mix the two solutions. Use rectified sulphuric ether that has been washed to remove alcohol and acidity, and indiarubber that has not been vulcanised. When the indiarubber has become well softened by the ether, break it up into small pieces, and stir well until a homogeneous soft mass is obtained. It will be as well to cut the rubber into small pieces before pouring the ether on, but the mass must be frequently and well stirred. Pour the solution of shellac into that of the rubber, and incorporate them thoroughly by stirring. This is a modification of the famous marine glue, and resists the action of water, both hot and cold, and most of the acids and alkalies. If the glue be thinned by the admixture of ether, and applied as a varnish to leather, along the seams where it is sewed together, it renders the joint or seam water-tight, and almost impossible to separate. (3) The following recipe, taken from 'New Remedies,' is said to yield a strong cement: 10 parts of indiarubber are dissolved in 120 of benzine with the aid of a gentle heat. When the solution is complete, which sometimes requires 10 to 14 days, 20 parts of asphalt are melted in an iron vessel, and the indiarubber solution is poured in very slowly, in a fine stream, and under continued heating, until the mass has become homogeneous, and *nearly all of the solvent has been* driven off. It is then poured out and *cast into greased tin moulds.* It forms dark brown or black cakes, which are very hard to break. This cement requires considerable heat to melt it; and to prevent it from being burnt, it is best to heat a capsule containing a piece of it first on a water-bath, until the cake softens and begins to be liquid. It is then carefully wiped dry, and heated over a naked flame, under constant stirring, up to about 300° F. (149° C.). The edges of the article to be mended should, if possible, also be heated to at least 212° F. (100° C.), so as to permit the cement to be applied at leisure and with care. The thinner the cement is applied, the better it binds. (4) Indiarubber, 15 to 20 gr.; chloroform, 2 fl. oz.; dissolved; powdered mastic, ¼ oz., is added. The cement must be kept well corked, and in a cool place, to prevent loss by evaporation. (5) Finely divided indiarubber, 1 part, is dissolved in naphtha oil, or crude naphtha, 40 parts. The solution is not completed in less than 10 or 12 days, and, in order to facilitate it, the mixture should be repeatedly agitated. To it, is then added gum lac, in the proportion of 2 parts by weight of lac to 1 of solution. The compound is then placed in an iron vessel over a fire, and constantly thinned till it becomes homogeneous. It is then poured on a cold surface, such as a slab of marble or a flag-stone, and left till cool, when it is broken up and put by for use. The indiarubber is sometimes omitted, in which case, the proportions will be 1 part of naphtha and 2 of lac. When required for use, the cement is heated at a temperature not exceeding 212° to 230° F. (100° to 110° C.), in a thick vessel of copper or cast iron, and is brushed in thin and even layers on the surfaces to be joined; these are then brought into close contact, and strongly pressed. If the surfaces are so wide that the cement becomes cool before the operation is finished, it is well to pass a hot iron—say at about *140° F. (60° C.)—over it. It is valu*able, not only for repairing broken wood, but also for cementing the moulds used in foundries, for caulking ships, for joining blocks of marble or granite, and for uniting wood and iron. It can be made as hard as desired, by increasing the proportion of lac. With the addition of bichloride of mercury dissolved in wood spirit, this cement might, with economy, replace the copper sheathing of ships. Wood, iron, plaster, and brick, to which it is applied, assume a varnished appearance; timber is rendered free from the attacks of insects and from liability to rot, and iron is preserved from rust.

Masons'.—(1) 20 lb. clean river sand, 2 lb. litharge, 1 lb. quicklime, sufficient linseed-oil to form a thin paste. Used for joining fragments of stone. (2) *Gad's.* 3 parts well-dried and powdered clay, 1 of iron oxide, mixed together and made into a stiff paste with boiled oil. Used for work required to harden under water. (3) For grotto work. Commonest sealing-wax. (4) An excellent cement for foot-walks, and for all uses which require exposure to the weather or to dampness, is described in 'Der Praktische Maschinen-Constructeur.' It is made by thoroughly stirring Portland cement or good hydraulic lime into a warm solution of glue, so as to make a thick paste, and applying it immediately. In three days it acquires extraordinary hardness and tenacity. It is an excellent cement for joining the porcelain heads to the metal spikes which are used as ornamental nails. (5) Fahnejelm recommends a mixture of 75 parts of carefully washed chalk and 25 parts of washed kaolin, to be first calcined to red heat, and afterwards ground. The powder is then snow white, or, if the heat has been too great, it has a bluish shade. Either alone, or with a small percentage of gypsum, it makes an excellent hydraulic cement. (6) 1 part yellow Botany Bay gum, 1 of brickdust, melted together. For stoneware. (7) 60 parts chalk, 20 of lime, 20 of salt, 10 of Barnsey sand, 5 of iron filings, 5 of clay; ground together, and calcined. Beale's. (8) 3 parts clay, 1 of slaked lime; mixed, exposed for 3 hours to full red heat, and ground to powder. Bruyere's hydraulic.

Mastic (various).—(1) Pulverised baked bricks, quicklime, and wood ashes, equal parts; mix thoroughly, and dilute with olive-oil; this mastic hardens almost immediately in the air, and never cracks beneath water.

Mastic for wood block floors.—(*a*) This consists of 3 parts pitch and 1 part Stockholm tar heated together and used hot. The mixture is poured into a wooden tray and each floor block dipped to the depth of the key, then pressed down in position. In some cases the mixture is poured on floor and the blocks pressed on to it. This is more comfortable to the hands, but not so good in results unless the man is experienced in his work. About 6 quarts is allowed to a square. (*b*) Coat the concrete or cement floor with Stockholm tar, then lay blocks with mastic composed of 100 parts asphalt to 1 part Stockholm tar, melted together and used hot. (*c*) 2 parts Stockholm tar, 1 part pitch heated together and thickened a little with about $\frac{1}{10}$-th quicklime.

Mastic for bedding wood sills on stone, etc.—(*a*) 3 parts dry red lead, and 3 parts sharp clean sand, to which is added 2 parts ground lias lime. Mix dry, then make into a stiff paste with boiled linseed-oil. (*b*) 1 part dry red lead, 8 parts dry brick dust, mixed to a paste with boiled linseed-oil. In applying see that surfaces are clean and dry, then coat with boiled oil and use the mastic as putty would be used.

Mastic for kitchen range and stove work.—Fine sharp sand, 28 lb.; powdered litharge, 14 lb.; quicklime, 4 lb.; linseed-oil to make a mass like putty.

Mastic Cement for Covering the Fronts of Houses.—50 parts, by measure, of clean dry sand, 50 of limestone (not burned) reduced to grains like sand, or marble dust, and 10 parts of red lead, mixed with as much boiled linseed-oil as will make it slightly moist. The bricks to receive it should be covered with 3 coats of boiled oil, laid on with a brush, and suffered to dry before the mastic is put on. It is laid on with a trowel like plaster, but it is not so moist. It becomes hard as stone in a few months. Care must be exercised not to use too much oil.

Serbat's Mastic.—Finely pulverised sulphate of lead is pounded together with 1 part of old linseed-oil in a suitable apparatus. Repeat the operation twice, adding each time 1 part of finely pulverised pyrolusite. It is then preserved in a stone vessel closed with wet bladder. *Another direction for preparing this mastic* is as follows: Triturate 5 parts of zinc oxide and 5 of sulphate of lead with about 4 of linseed-oil, then add gradually 10 parts of finely ground pyrolusite and a like quantity of colcothar, and pound the whole in a cast-iron mortar with an iron pestle, adding gradually 100 parts more of pyrolusite and a like quantity of colcothar. The cement is good when sufficiently thick, and at the same time so flexible that it can be rolled out between the fingers without breaking. If the cement has become hard add some more oil and work it thoroughly with the iron pestle.

Meerschaum.—(1) The best cement for joining pieces of meerschaum, is *Egg Cement*, which see. (2) Garlic, crushed to form a sort of dough, is rubbed over the surfaces of the meerschaum to be united; the latter are then bound tightly together with fine wire, and boiled in milk for half an hour. (3) Quicklime is mixed to a thick cream with the white of an egg. These cements will also join fragments of glass or china.

Metal to Glass, Stone, Etc.—For attaching metal plates, such as letters, etc., to flat sheets of glass, the following may be used: (1) Copal varnish, 15; drying-oil, 5; turpentine, 3. Melt in a water-bath and add 10 parts slaked lime. (2) Copal varnish, 15 parts; boiled linseed-oil, 5; Venice turpentine, 5; glue, melted in the smallest possible quantity of water, 5 parts. Melt together and add 10 parts of powdered quicklime. (3) Carpenter's glue, 4 parts; Venice turpentine, 1. (4) Rosin is melted, and into it is stirred calcined plaster till the mass is reduced to a paste, to which is added boiled oil, in sufficient quantity to bring it to the consistence of honey. It is applied warm. (5) Into melted rosin, 180 parts, are stirred burnt umber, 30 parts; calcined plaster, 15 parts; boiled oil, 8 parts. (6) Rosin, 4 to 5 parts; wax, 1 part; colcothar, 1 part; the whole melted together. A little powdered plaster is often added. (7) Sandarac or galipot varnish, 15 parts; boiled linseed-oil, 5 parts; turpentine, 2½ parts; essence turpentine, 2½ parts; marine glue, 5 parts; pearl white, 5 parts; dry carbonate of lead, 5 parts; mixed. (8) Copal or lac varnish, 15 parts; drying oil, 5 parts; indiarubber, or guttapercha, 4 parts; coal oil, 7 parts; Roman cement, 5 parts; plaster, 5 parts. (9) Copal or rosin varnish, 15 parts; turpentine, 2½ parts; essence of turpentine, 2½ parts; fish isinglass, in powder, 2 parts; iron filings, 8 parts; ochre or rottenstone, 10 parts. These cements are much used for fixing metallic letters to glass, marble, or wood. The two following are particularly good for uniting brass and glass: (10) Caustic soda, 1 part; rosin, 3 parts; plaster, 3 parts; water, 5 parts, the whole is boiled. This compound hardens at the end of half an hour; the hardening may be retarded by replacing the plaster by zinc white, white lead, or slaked lime. (11) Fine litharge, 2 parts; white lead, 1 part; copal, 1 part; boiled linseed-oil, 3 parts; the whole is triturated together. (12) For joining metallic surfaces, where soldering is inconvenient, recourse may be had to a composition formed in the following way: Pure and finely divided copper, such as that obtained by the reduction of sulphate of copper with zinc clippings, 20 to 36 parts, according to the degree of hardness desired in the cement, dissolved in a sufficient quantity of sulphuric acid to make a thick paste; with this is incorporated, by trituration in a mortar, mercury, 70 parts. The mass is soft, but hardens at the end of some hours. For use it is heated to 212° F. (100° C.), and powdered in an iron mortar heated to 302° F. (150° C.); it then assumes the consistence of wax, and is harder in proportion as it contains more copper. It adheres strongly on drying. (13) To obtain a cement suitable for joining metals and non-metallic substances, mix liquid glue with a sufficient quantity of wood-ashes to form a thick mass. The ashes should be added in small quantities to the glue while boiling, and constantly stirred. A sort of mastic is thus obtained, which, applied hot to the two surfaces that are to be joined, makes them adhere firmly together. (14) A similar substance, may be prepared by dissolving in boiling water, 2¼ lb. of glue and 2 oz. of gum ammoniacum, adding, in small quantities, about 2 oz. of sulphuric acid.

Microscopical.—A cement invented by Dr. J. G. Hunt, is prepared as follows: Take dammar gum, any quantity, and dissolve it in benzole; after obtaining a solution just thick enough to drop readily from the brush, add enough of the finest dry oxide of zinc previously triturated in a mortar with a small quantity of benzole, until the solution becomes white when thoroughly stirred. If not too much zinc has been added, the solution will drop quickly from the brush, flow readily, and dry quick enough for convenient work. It will adhere, if worked properly, when the cell cover is pressed down, even when glycerine is used for the preservative medium; keep in an alcohol-lamp bottle with a tight lid and secure the brush for applying the cement in the lid of the bottle. Its advantages lie in the circumstance that the glass cover can be placed upon the ring of it whilst still fresh and soft, and that in drying it adheres to both cover and slide, so as to form a joint between them of the width of the ring of cement, and not, as with asphaltum, gold-size, etc., simply at the edge and upon the outside of the cover. The method of mounting with it is as follows: A ring of any desired size is made by means of an ordinary Shadbolt's turntable, upon a slide, which is then placed to one side to dry; when required for use, the specimen, cover, etc., being all prepared and ready, the slide is again placed upon the turntable, and a new ring of cement put directly upon the old one. The specimen is immediately placed within the cell thus formed, and the requisite quantity of carbolated water placed upon it. The cover which must be large enough to entirely or nearly cover the cement ring, is now picked up with the forceps, the under side being moistened by the breath to prevent adhesion of air-bubbles, and carefully placed in position. It is now to be carefully and equably pressed down with some force; by this any superfluous water is squeezed out, and the cover is forced down into the cement, which rises as a little ring around its edge. The pressure is best made with a stiff needle, at first on the centre, and then upon the edges of the cover, which may finally be made slowly to revolve beneath the needle point. The slide may then be put aside to dry; or, better, an outside ring of the cement put over its edge in the usual way. If time be an object, and only a shallow cell be required, the first ring of cement may be dispensed with, and the whole mounting be done in a few minutes. (2) According to Dr. L. Heydenreich of St. Petersburg, the best cover-glass should be: (*a*) Absolutely hermetic, and should not, under any circumstances, require renewal every year. Two or three coats of the cement, applied at short intervals after an object is mounted, should permanently secure and preserve the object. (*b*) It should be as hard as glass, or, if possible, harder. (*c*) It should not crack nor become detached, and should be so solidly adherent as to be less likely to break than the glass to which it is attached. And (*d*) It should be insoluble in water or glycerine, or in any liquid used as an immersion medium with objectives. Notwithstanding the large number of cover-glass cements already known and in use, he thinks another should be sought for—one which shall conform to the foregoing requirements. We have commercial varnishes, which are very hard and durable. Some of them, used in the finishing of carriages, are found, after the lapse of a year, to be in the same condition as when first applied. The varnish used on tin pans in albumen factories remains unchanged for a year, although subjected daily, for many hours, to a temperature of 100° R. (257° F.). These and similar varnishes are made of resins, copal, or amber. Of all resins, amber and some kinds of copal are the hardest. Copal varnish is both hard and elastic; amber varnish is harder than copal, but not so elastic, and is, consequently, more brittle: hence, for a cover-glass cement, a mixture composed of both should be used. Only the best and clearest kinds of amber (the opaque pieces contain various kinds of minerals), and only the hardest kind of copal—that is, the East-India or Zanzibar copal—should be selected for cover-glass cements. Zanzibar copal is taken from the earth in flat, disc-shaped pieces, varying in dimensions from the size of a pea to the size of the human hand; is colourless, yellow, or of a dark red-brown colour, and transparent; the surface, rough. Bombay copal comes in larger pieces, is of a yellowish-red colour, has, when broken, a smooth, glassy surface, and is but very slightly inferior in quality to the copal of Zanzibar. Sierra-Leone copal comes in small, ball-shaped pieces, about 1 in. in diameter, or in pieces resembling drops in shape. All the other kinds are softer than those just described. The best solvent for resin, and the one which possesses the most adhesive quality, is linseed-oil varnish, made of pure, old linseed-oil. Neither alcohol, ether, chloroform, nor any other quickly evaporating menstruum should be used. In order to hasten dessication of the resin, and to obtain for the cement the proper consistency, an ethereal oil which, upon drying, will leave a surface perfectly even, should be added to the mixture; and oil of lavender, either alone or mixed with linseed-oil varnish, is suitable for these purposes. The resins being thus dissolved in linseed-oil varnish until the solution attains the consistency of syrup, oil of lavender should be added until the mixture becomes thin enough to use in mounting microscopical objects—and the cement is finished. The property of adhering to glass is increased in the cement by adding to it a small quantity of cinnabar; but such addition causes it to dry less rapidly. In a week from the time of using it the cement becomes dry, and so firm that the finger-nail will make but a slight impression on it. For months it remains in this condition. At the expiration of a year, it is very hard, and has a glassy surface.

So much for the component parts. The preparation of this cement being somewhat difficult it would perhaps be advantageous to buy the varnishes ready made, and then proceed as follows: Taking equal parts of the best, clearest, and hardest amber-varnish and copal-varnish, mix them and heat until all the turpentine has disappeared. This will require a temperature of 100° to 150° R. (257°–370° Fahr.). As soon as all the turpentine has evaporated, remove the dish from the flame, allow it to cool somewhat, and then add oil of lavender to the liquid in proportion of ½ to 1; mix well, and allow the entire mass to cool thoroughly. The process is terminated by adding from 20 per cent. to 40 per cent. of artificial cinnabar (rosin with cinnabar), which should be very carefully and thoroughly rubbed in. The best method for rubbing in the cinnabar is that employed in the preparation of fine oil-paints. Should the cement when finished be too thick for use, as much oil of lavender as will give the required fluidity may be added. The component parts and their proportions would then be as follows:—

Amber	25	parts.
Copal	25	,,
Linseed-oil varnish .	50	,,
Oil of lavender . .	50–60	,,
Artificial cinnabar .	40–60	,,

Dr. Heydenreich continues his article by describing the manner in which the cement should be applied, but as his method is the same as that employed in the use of Canada balsam and other cover-glass cements, and, consequently, familiar to all microscopists, it is not necessary to make a note of it. However, he advises, in order to secure a perfect mount, that a second ring be made after the first or second week from the time of mounting; and a third, after the first or second month; each additional ring to be slightly wider than the preceding one. (*And see* CANADA BALSAM.)

Milk.—This cement is not so generally known as it ought to be. It is the simplest and best domestic cement for repairing china and crockery. The process consists simply in tying the parts firmly together and boiling them in skimmed milk. The tying together of the pieces of a round cup or bowl is not a very simple matter, but it can be done by going the right way to work. First, arrange the parts in their proper positions, and, if a bowl, set it mouth down, as the pieces will keep their arrangement best in this position. Then wind stout tape round the article, so as to hold the pieces together. Tape is far better than twine, and pieces should be kept for this purpose. It is easy to draw the tape tight until we come to tie the ends, and then special devices must be used.

When sufficient tape has been wound round the article, let one person hold it from slipping by pressing a finger firmly on each end, and then let another person tie the ends in a firm knot, but leaving the tape so loose from the article that a pencil or stout skewer may be passed under it. Then by twisting the skewer the tape is tightened in the same way that a surgeon compresses an artery with his tourniquet, and by passing the fingers over the tape, and smoothing it forward toward the ends, all the pieces may be pressed together with a firmness that cannot be obtained in any other way. The article should now be placed in a pan of cold milk (skim-milk is the best and cheapest), which should be gradually heated to the boiling-point, and kept at this temperature for some time—say ½ to 1 hour—care being taken not to allow it to burn. The articles are allowed to cool in the milk, and when taken out are wiped dry and allowed to stand for a day or two until the cement has become quite hard. They may then be washed off with warm water, and the parts will be found to be strongly cemented together. The same milk may be used again, but not with such good effect. Generally, however, it is possible to pack quite a number of articles in the pan in the first place, especially if they can be "nested," or placed one within the other.

Mucilage.—Stir 2½ lb. potato starch into 8 pints cold water and add 2 oz. pure nitric acid. Let stand in a warm place for about 2 days, stirring occasionally. Next boil until the mass becomes thick and translucent, after which dilute with water if required and filter through cloth.

Naturalists'.—Consists of mucilage of gum arabic, thickened with starch powder or farina, with the addition of a little lemon-juice. Sometimes the mucilage is used alone. This cement is employed by naturalists, for mounting specimens; by artificial flower makers; by confectioners, to stick ornaments on their cakes, etc.

Opticians'.—The cements obtained from the following formulæ are used by opticians for fixing lenses, prisms, etc., to chucks and holders, while they are being ground. (1) Pitch, 5 parts; wood ashes, 1; tallow, 1, less or more, according to the temperature of the season. (2) Shellac softened with rectified spirit or wood naphtha. (3) Beeswax, 1 oz.; resin, 15 oz.; melt and add 5 oz. of whiting previously heated red hot and still warm. (4) Resin, 1 lb.; melt and add dry and warm plaster 4 oz. This forms a very strong cement for rough purposes.

Parabolic.—This is a variety of casein or cheese cement, prepared as follows: Curdle skim-milk with rennet or vinegar, press out the whey, and dry the curd by a very gentle heat, but as quickly as possible. When quite dry, grind it in a pepper or coffee mill, and triturate it in a mortar until reduced to a very fine powder. Mix 10 parts by weight of this powder with 1 of quicklime, also in very fine powder, and to every ounce of the mixture add 5 or 6 gr. of camphor. Triturate the whole together, and keep in phials well corked. Used to unite glass, earthenware, etc., which it does very strongly. It is made into a paste with a little water as wanted, and applied immediately.

Parchment Paper.—The best cement for pasting parchment paper is casein glue. It is much better than so-called chrome glue, because the latter produces yellow or brownish spots where it has been employed. Casein glue is a solution of casein, which appears as whey or drop when milk is allowed to curdle. The glue is dissolved in a saturated solution of borax. When dried in the form of transparent gelatine, it appears as greyish white and somewhat brittle matter, which can be easily dissolved in water, and possesses great adhesiveness When employed for pasting parchment paper, a thin paste is prepared, used in the customary manner, and the jointed places are afterwards exposed for a little while to a jet of steam.

Parian.—Same as Keene's marble cement (*see* MARBLE) substituting a solution of borax for one of alum.

Paris.—This cement is used for mending shells and other specimens of natural history. It is composed of gum arabic, 5; sugar candy, 2; white lead, enough to colour.

Paste.—Next to glue, paste is the most extensively used, and the most valuable cement that we have. For ordinary purposes it consists simply of flour, made into a thin cream with water, and boiled. It then forms a stiffish mass, which may be diluted with water so as to bring it to any required condition of thickness. There are two distinct elements in flour, both of which are valuable, one is starch, and the other is gluten. The cheaper kinds of flour, and especially rye flour, are rich in gluten, while wheat flour is rich in starch. In the latter case, it is sometimes of advantage to add a little common glue to the paste. For ordinary purposes no additions are necessary, but where paste is to be kept for a long time, various ingredients may be added, to prevent souring and moulding. A few cloves form, perhaps, the best preservative for small quantities. On the larger scale carbolic acid may be used. According to Lunge, souring and moulding may be entirely prevented by the addition and thorough mixture with the freshly-prepared paste of a few gr. of salicylic acid. When thus treated, a paste may be kept for weeks in a heated room without loosing its freshness, and even when it has, by long standing, become dry and tough, may be at once rendered fluid and serviceable by treatment with hot water. The addition of the acid does not, according to this author, affect the stickiness of the paste to any sensible degree. When it is desired to prevent the attacks of insects, either before or after use, the addition of corrosive sublimate is a sure preservative, but as this substance is a powerful poison, great care must be exercised when it is employed. The following formulæ give good results:—

(1) *Starch Paste.*—This is best prepared by triturating the starch with cold water in a mortar until no lumps remain, and not too thick a mass is formed, and pouring into this boiling water very slowly, with rapid stirring, until the paste begins to form, as indicated by the increase of transparency, and then rapidly adding the rest of the boiling water necessary for the paste. Boiling the paste is very injurious, rendering it less adhesive, and liable to peel off. Rye flour affords a more adhesive paste than starch, but of a grey colour. The addition of a little alum to the water with which paste is prepared renders it more permanent, and the use of boiling lime-water instead of pure water adds to its adhesiveness. An aqueous extract of decomposed gluten, however, affords the best paste with starch. By incorporating with the paste a quantity of turpentine, equal in weight to half of the starch employed, and stirring well while the paste is still hot, it will be rendered more impervious to moisture, and at the same time more adhesive.

(2) *Corn Starch Paste.*—Corn starch makes a good paste for scrap-books. Dissolve a small quantity in cold water, then cook it thoroughly. Be careful and not get it too thick. When cold it should be thin enough to apply with a brush. It is not so liable to mould and stain the paper as paste made from other kinds of starch.

(3) *Paste for Mounting Photographs.*—Mix thoroughly 630 gr. of the finest Bermuda arrowroot with 375 gr. of cold water in a capsule, with a spoon or brush; then add 10½ oz. of water and 60 gr. of gelatine in fine shreds. Boil, with stirring, for 5 minutes, or until the liquid becomes clear, and when cold stir in well 375 gr. of alcohol, and 5 or 6 drops of pure carbolic acid. Keep in well-closed vessels, and, before using it, work up a portion with a brush in a dish.

(4) 4 parts, by weight, of glue are

allowed to soften in 15 parts cold water for some hours, and then moderately heated till the solution becomes quite clear; 65 parts boiling water are now added with stirring. In another vessel, 30 parts starch paste are stirred up with 20 of cold water, so that a thin milky fluid is obtained without lumps. Into this the boiling glue solution is poured, with constant stirring, and the whole is kept at the boiling temperature. After cooling, 10 drops of carbolic acid are added to the paste. This paste is of extraordinary adhesive power, and may be used for leather, paper, or cardboard with great success. It must be preserved in closed bottles to prevent evaporation of the water, and will, in this way, keep good for years.

(5) Fine wheat starch, 1 oz.; beat into a paste with cold water; best glue, 4 oz. Soak the glue, and when soft, boil it and add the starch paste, stirring well. Boil the whole until it is quite thick, and set aside to cool. It keeps well, and when required for use may be instantly dissolved in a little warm water.

(6) 2 oz. starch, 1 oz. white glue, ½ oz. acetic acid, a few drops of oil of cloves. Dissolve the glue in cold water and then boil. Mix the starch with cold water, and pour into the glue while boiling.

(7) Rice flour makes an excellent paste for fine paper work.

(8) Gum tragacanth and water make an ever-ready paste. A few drops of any kind of acid should be added to the water before putting in the gum, to prevent fermentation. This paste will not give that semi-transparent look to thin paper, that gum arabic sometimes gives, when used for mucilage.

(9) *Paste that will not sour.*—Dissolve 4 teaspoonfuls of alum in 1 gal. water; when cold, stir in as much flour as will give it the consistency of thick cream, beat smooth, add 1 teaspoonful of pulverised rosin, and 20 drops oil of cloves, pour the whole into 2 qt. boiling water, stirring thoroughly until it is cooked; pour into a glazed earthen vessel, and when cold cover the top with oiled silk, and put it in a cool place; when needed for use, take out a portion and soften with warm water. This will be found very convenient for use at times when very little paste is required at once.

(10) *Paste for Paperhanging.*—Take ½ quartern of flour (best biscuit) and put it into a pail, with a small portion of alum, broken up small; mix it up into a stiff batter with warm water; have ready a large saucepan of boiling water, and pour it over the paste, stirring well all the time, or it will be "lumpy." If properly done, it will thicken as the boiling water is poured over it; if it does not thicken, set it over the fire a few minutes, but be sure you stir it, or it will burn. When well thickened, throw a dash of cold water over it, as it prevents it skinning whilst cooling. Use rather thin. You can thin it with cold water.

(11) *Trimmers' Paste.*—Trimmers' paste requires to be smooth, elastic, as free from moisture as possible, and possessed of great adhesive qualities. If too moist, it will soil the cloth or silk to which it is applied, and if not well cooked it will mould and rot; its adhesive qualities are dependent upon the materials of which it is made, and the manner of mixing and cooking. The materials used are wheat and rye flour. The paste of commerce is made of a very low grade of wheat flour, cooked by steam; it is not a good article for trimmers, as it contains too much surplus moisture. To make wheat paste, select a low grade, but sweet wheat flour, and stir it into cold water, until thoroughly dissolved; then place the kettle over a quick fire and stir until it boils; it should be allowed to cook 5 or 6 minutes after it is brought to a boil, and be well stirred while boiling and until it is cool; if made in this way, it will contain no surplus moisture, and will be smooth and free from lumps. For rye paste, select good fine rye flour, place the necessary amount of water in a kettle

over a quick fire, and when the water boils pour in the flour slowly, stirring it thoroughly; continue to add flour until the desired thickness is obtained; then allow it to boil about 5 minutes, after which remove it from the fire and continue to stir until boiling ceases, then cover and allow it to stand until it is cold. Rye flour paste made in this way is the smoothest, most adhesive, and elastic paste in use. It is particularly valuable for pasting cloth on wood or leather. The dry paste that gathers on the kettle should not be thrown away; if it is soaked in cold water until it becomes soft, and again heated up to boiling heat, it is stronger and more elastic than when first made. Wheat or rye paste can be preserved from mould, etc., by adding a little carbolic acid or essential oil. The addition of a little dissolved gum arabic adds materially to the adhesive qualities of flour paste. Paste for summer use that will keep a long time is made of rye paste, prepared as above; when cold, pour it on a smooth board and set it in the sun to dry; when dry it can be broken up and saved for use. To prepare it for use, place a small quantity in a kettle and cover it with cold water; allow it to remain until soaked soft, then pour off the surplus water, place the kettle over a quick fire, and stir it until it boils. Another plan is to cook the paste, pour it on a cloth, lay it in a clean, warm place for 10 or 12 hours, roll up the cloth, and lay aside for use. Paste treated in this way will keep sweet for a week or more, even in the hottest weather.

Paste, Bookbinders'.—Place half a quartern of flour in a saucepan, put as much cold water on it as will cover it, and stir it well up, so as to break all the lumps while in a state of dough. Then pour on about 2 quarts of cold water and 1 oz. of powdered alum. Stir well and boil till it becomes thick.

Petroleum, to withstand.—If glue or gelatine is melted and mixed with glycerine, it can be made liquid by heat but goes to a stiff elastic substance when cold. This is not soluble to petroleum or benzine.

Plasters. — (1) Plaster-of-Paris, baked and ground, acquires great hardness and solidity when left for 24 hours, in contact with a solution of alum, and when, after drying in the air, it is submitted to a second baking. (2) Still better results are obtained by employing an aqueous solution containing $\frac{1}{10}$ of borate and $\frac{1}{10}$ of cream of tartar; the plaster, baked and in fragments, is plunged into this solution until it is saturated; then it is calcined, and pulverised. (3) A mixture of silicate of potash, 100 parts; carbonate of potash, 27 parts; and water, 500 parts, may also be used.

Plaster Casts.—To repair broken articles in plaster dissolve small pieces of celluloid in ether; decant the liquid after a short while. The pasty residue is a cement that will dry rapidly and not dissolve in water if the articles should be exposed to it.

Plumbers'.—Black rosin, 1 part; brickdust, 2 parts. The brickdust should be finely powdered, thoroughly dried and added to the rosin when the latter is in a melted state.

Porcelain. — (1) Add plaster-of-Paris to a strong solution of alum till the mixture is of the consistency of cream. It sets readily, and is said to unite glass, metal, porcelain, etc., quite firmly. It is probably suited for cases in which large rather than small surfaces are to be united. (2) Milk is coagulated by means of acetic acid, and the casein thus formed is well washed in water, and then dissolved in a cold saturated solution of borax; a clear solution is thus obtained which is superior to gum arabic in adhesive power, and is colourless. For porcelain, this liquid is mixed with finely powdered quicklime, and the resulting cement is quickly brushed over the fractured surfaces, which are then bound together; the ware is then dried at a gentle heat. ('Dingler's Polytech. Jl.') (3) To resist heat. It is made of Stourbridge clay mixed with a little tow or asbestos to increase its coherence. It should be well beaten before application; the glass or china should be first rubbed over with a little of the cement mixed with water, taking care to press the two edges of the glass or china together. This cement will bear a very strong heat. (4) Take isinglass ½ oz., proof spirit sufficient to dissolve it; to every 2 dr. add finely powdered mastic and finely powdered gum ammoniacum—of each 10 gr. Stir till dissolved. In using, heat the edges to be joined, and let the cement get thoroughly dry before using the article. The gums should be added to solution of isinglass when hot. (5) Calcine oyster-shells; pound and sift them through a sieve, and grind them on a flat smooth stone with a muller, till reduced to the finest powder; then take white of egg, and form the whole into a paste. Join the pieces of glass or china and press together 6 or 7 minutes. This cement will stand both heat and water, and will never yield, if properly done. (6) Plaster-of-Paris and gum. For very small articles this cement answers very well, but must not be too thick when well mixed.

Prints.—Fine wheat starch, 4 dr., beat into a paste with cold water; 1 oz. of best Russian glue dissolved in a pint of boiling water; while boiling, pour on the starch; put the whole into a saucepan, and boil till as thick as treacle. When required for use a small quantity is to be melted in a little warm water.

Putty.—(1) Good putty, for general purposes, is composed of raw linseed-oil and whiting thoroughly incorporated, and can be made equally well by hand or machinery. The whiting should be dry. Linseed-oil foots or "bottoms" is only used on the score of economy—that is, to use up a material that would be objectionable in paint. In the shop, putty is made by hand in winter, for summer use, on the putty bench. Dry sifted whiting is mixed with as much oil as will enable it to be *well beaten with a mallet* (an essential feature in making putty is to *beat it*) and well kneaded into lumps about the size of a 4 lb. loaf, which are then ranged on a shelf, and left for a week, by which time it will be found they have become very soft. More whiting is now worked in, after which pack in casks, pressing it well down. This putty improves by keeping a few months—that is, gets tougher and more homogeneous. (2) A very strong putty is made of boiled oil and whiting for exposed situations, as skylights, but is not adapted for keeping—it gets too hard. (3) Putty for good inside work is improved by adding white lead. (4) Another putty which requires to be made as wanted (as it gets hard almost immediately) is composed of red lead in powder mixed with boiled oil and turpentine varnish, and is used for fronts of houses or any place requiring a hard putty. (5) Some manufacturers prepare an oil for the purpose by melting 20 lb. rosin and mixing it with 90 lb. linseed-oil, the rosin being used for economy sake. (6) For some purposes a drying-oil may be used with the whiting: this is made by mixing 1 gal. linseed-oil, 12 oz. litharge, 1 oz. sugar of lead, 1 oz. white vitriol, simmer for some time, allow to cool, and when settled draw it off. (7) *French putty.* Ruban prepares this substance by boiling linseed-oil (7 parts) with brown umber (4 parts) for two hours; 5½ parts of chalk and 11 of white lead are then added, and the whole well mixed. This putty is very durable, and adheres well to wood, even though not previously painted.

Sealing Wax. — *See* SEALING WAX, MANUFACTURE OF.

Shellac.—(1) Shellac, made up into sticks of the size of a lead pencil, is frequently sold as a cement which will resist water, acids, oils, etc., and it answers very well. Sometimes it is mixed with very fine powders, either to give it body, or to colour it. Zinc white or plaster-of-Paris may be used to make it white; ivory black, for black; brickdust, red ochre, and vermilion for different shades of red. The objects to be cemented together are first warmed till they melt the shellac brought into contact with them. This is very good to cement broken glass, porcelain, etc., especially as the objects are again ready for use immediately when cold; but it is not adapted for flexible objects, as it cracks. It will not withstand heat or alcohol, which softens the shellac. Shellac is soluble in alcohol, when it forms what is known as Chinese glue. It is also soluble in wood naphtha. Contrary to published statements to that effect, shellac does not form as strong a cement when in the state of solution as when melted by heat. Instead of using alcohol or benzine, a watery solution of borax may be used for dissolving shellac. Take of borax, 100 parts; rain (or distilled) water, 2250 parts; heat to boiling, and while stirring, gradually add powdered shellac, 300 parts. When dissolved, strain through muslin and preserve. This forms a waterproof varnish. Paper soaked with this is waterproof, and resembles parchment. Shellac makes the best black cement for articles of jet. It is made black by smoking it in the flame of a lamp or candle.

(2) *Hoenle's.*—Shellac, 2 parts; Venice turpentine, 1; fuse together and form into sticks. (3) It is sometimes necessary to pulverise shellac. A correspondent of the 'Druggists' Circular' has devised the following method: "Enclose the shellac in a strong, closely-woven piece of cloth, at first compressing the folds rather tightly, but gradually relaxing them. Then, after placing the bunch, which must be held in position with the hand, upon a solid block or smooth counter, the strokes of a heavy iron pestle are applied, gently at first, while the bunch is kept moving from side to side, so as to expose every part to the strokes of the pestle. After the large, sharp pieces are broken, the strokes are increased in velocity and power, with wonderful effect upon the resin, and but little injury to the cloth. In this way shellac may be reduced to granular form sufficiently fine for pyrotechnic purposes at very short notice, and to an almost impalpable powder in a comparatively short space of time. To produce this result, however, it is necessary to wield the pestle forcibly, and then from time to time separate the finer particles from the coarser by sifting."

Soluble Glass.—When finely pulverised chalk is stirred into a solution of soluble glass of 30° B. until the mixture is fine and plastic, a cement is obtained which will harden in 6 or 8 hours, possessing an extraordinary durability, and alike applicable for domestic and industrial purposes. It may be used for uniting stone, brick, etc., and for filling up cracks. In short, it seems to be applicable to about the same purposes for which plaster-of-Paris is used, but it is much harder and stronger. If for part of the chalk some colouring matter be substituted, differently coloured cements of the same general character are obtained. The following materials give good results: (1) Finely pulverised or levigated stibnite (grey antimony, or black sulphide of antimony) will produce a dark cement, which, after burnishing with an agate, will present a metallic appearance. (2) Pulverised cast iron, a grey cement. (3) Zinc dust (so-called zinc grey), an exceedingly hard grey cement, which, after burnishing, will exhibit the white and brilliant appearance of metallic zinc. This cement may be employed with advantage in mending ornaments and vessels of zinc, sticking well to metals, stone, and wood. (4) Carbonate of copper, a bright green cement. (5) Sesquioxide of chromium, a dark green cement. (6) Thénard's blue (cobalt blue), a blue cement. (7) Minium, an orange-coloured cement. (8) Vermilion, a splendid red cement. (9) Carmine red, a violet cement.

Sorel's.—There are two different cements which go by the name of Sorel's: namely, the "oxychloride of zinc" and the "magnesia" cement.

(1) *Oxychloride of Zinc.*—A solu-

tion of chloride of zinc is prepared by dissolving zinc in hydrochloric acid, so that some metallic zinc always remains undissolved. The solution is filtered and concentrated until it has the sp. gr. 1·800. Commercial oxide of zinc is mixed with water containing 2 per cent. of nitric acid to a stiff paste, which, after being dried, is heated in crucibles to a white heat, after which it is reduced to an impalpable powder. The object of this baking is to reduce the oxide to as small a bulk as possible, in which condition it has more binding power. The powder must be kept from contact with the air, to prevent access of moisture and carbonic acid gas. On bringing together the oxide and solution of chloride of zinc, the whole solidifies in a few minutes to a very hard mass. If it is desired to retard the hardening, the zinc solution may be diluted to about 1·500–1·600 sp. gr., and the oxide of zinc may be mixed with 2 to 3 per cent. of borax or chloride of ammonium.

(2) *Magnesia.*—This was originally prepared from magnesite (chiefly native carbonate of magnesium), by making a paste with powdered magnesite, 10 to 20 per cent. of hydrochloric acid, and a sufficient quantity of water, forming the mass into bricks, then burning them at a strong heat, and finally grinding them. This yields a very hard, bright-coloured cement, which bears large dilution with sand, but is not entirely waterproof. Since the immense saline deposits at Stassfurt have been worked, this cement is prepared from kieserite (a native hydrated sulphate of magnesium), many thousand tons of which are annually obtained. Kieserite is mixed with calcium hydrate, in the proportion of two molecules of the former to one of the latter, with addition of water; the mass is formed into bricks or cakes, dried, and "burnt," and powdered. The powdered mass when moistened solidifies to a marble-like mass, which does not, however, permanently resist moisture, and is best used only in the interior of buildings.

(3) The following composition forms an excellent material for moulding or for uniting stone, etc. Mix commercial zinc white with ⅓ its bulk of fine sand, adding a solution of chloride of zinc of 1·26 sp. gr., and rub the whole thoroughly together in a mortar. The mixture must be applied at once, as it hardens very quickly.

Steam.—The lutes usually employed for making steam-tight joints are composed of white lead and litharge in various proportions. (1) A steam-tight cement which is said to be superior to the ordinary white-and-red lead cement, is obtained by mixing 6 parts of finely pulverised graphite, 3 of slaked lime, 8 of sulphate of baryta, and 7 of boiled linseed-oil. These ingredients must be intimately mixed. (2) Dried and powdered clay, 6 lb.; iron filings, 1 lb.; made into a paste with boiled linseed-oil; used for stopping cracks and leaks in boilers, stoves, etc. (3) Litharge in fine powder, 2 parts; very fine sand, 1; lime that has been allowed to slake spontaneously in a damp place, 1: mixed, and kept from the air; made into a paste with boiled oil, and used to mend cracks, and secure steam joints. (4) Good linseed-oil varnish ground with equal weights of white lead, oxide of manganese, and pipeclay. (5) Dry, powdered clay, 1 part; clean, sifted iron filings, 2; acetic acid, sufficient to make a paste. (6) Dry, powdered clay, 8 to 10; iron filings, free from rust, 4; peroxide of manganese, 2; sea-salt, 1; borax, 1; water, sufficient to make a paste. (7) Sulphate of baryta, 1 part; clay, 2; made up with solutions of silicate of potash, and borax; it resists a very high temperature. (8) Iron filings, free from rust, 50 parts; flowers of sulphur, 2; pulverised hydrochlorate of ammonia, 1; these substances are mixed with water or urine, so as to make a solid and homogeneous paste, which is used in the joints of steam boilers. The lute swells, becomes very solid, and perfectly closes the joints. (9) Iron filings, 4 parts; loam, 2; powdered sandstone, 1; made into a paste with salt water; becomes very hard on setting. (10) A thick paste, composed of silicate of soda and iron filings; the latter substance may be replaced by a mixture, in equal parts, of powdered oxide of zinc and peroxide of manganese. (11) Sand, 84 parts; Portland stone, 166; litharge, 18; pulverised glass, 0·90; red lead, 0·45; suboxide of lead, 0·90; the whole rubbed up with oil.

Stone.—(1) Sulphur, 1 part; yellow wax, 1 part; rosin, 1 part; the sulphur and rosin are melted, and the wax is then added. It is necessary to heat the surfaces to be united; the cement is applied while still hot, and pressure is exerted till it is cold. (2) Powdered gum arabic, 2 parts; finely ground white lead, 2 parts; pulverised sugar-candy, 1 part; the three substances are placed in a small bottle with a wide mouth, a little hot water is poured on them, and the whole is stirred by a stick into a homogeneous paste. The cement must be kept in a closed vessel, and a little water may be added if it becomes dry. Before use, it must be well stirred, to prevent the white lead collecting at the bottom. It is employed for joining fragments of minerals, fossils, etc. (3) The following metallic cement for repairing broken stone was, according to Professor Brune, of the School of Fine Arts, used in the restoration of the colonnade of the Louvre, of the Pont Neuf, and of the Conservatoire des Arts et Metiers. It consists of a powder and a liquid. The powder: 2 parts by weight of oxide of zinc, 2 of crushed limestone and 1 of crushed grit, the whole intimately mixed and ground. Ochre in suitable proportions is added as a colouring matter. The liquid: A saturated solution of zinc in commercial hydrochloric acid, to which is added a quantity by weight, of hydrochlorate of ammonia equal to one-sixth that of the dissolved zinc. This liquid is diluted with two-thirds of its bulk of water. To use the cement, 1 lb. of the powder is to be mixed with 2½ pints of the liquid. The cement hardens very quickly and is very strong. (4) Another cement is made by boiling slices of skim-milk cheese or curd into a gluey consistence in water, and then incorporating it with quicklime on a slab with a muller, or in a marble mortar. When this compound is applied warm to broken edges of stoneware, it unites them very firmly after it is cold.

Stonemasons'.—Clean river sand, 20 lb.; litharge, 2 lb.; quicklime, 1 lb.; linseed-oil, sufficient to form a thin paste. This cement is applied to mend broken pieces of stone, and after a time it becomes exceedingly hard and strong. A similar composition has been used to coat brick walls, under the name of mastic.

Turners',—(1) Melt 1 lb. resin in a pan over the fire, and when melted, add ¼ lb. of pitch. While these are boiling add brickdust until, by dropping a little on a cold stone, you think it hard enough. In winter it may be necessary to add a little tallow. By means of this cement, a piece of wood may be fastened to the chuck, which will hold when cool; and when the work is finished, it may be removed by a smart stroke with the tool. Any traces of the cement may be removed from the work by means of benzine. (2) The heat necessary to melt the ordinary turners' cement is liable to warp thin plates of brass, and in some cases, as for example circles of mathematical instruments that require to be graduated, this is very objectionable. In such cases plaster-of-Paris is the best cement to use. (3) ½ oz. rosin, ½ oz. pitch, 1 oz. beeswax; melted together, sufficient fine brickdust added to produce desired consistence. (4) 2 lb. rosin, 2 lb. Burgundy pitch, 2 lb. dried whiting, 2 oz. yellow wax; melted and mixed together. (5) ½ lb. black rosin, 1 oz. yellow wax; melted together, and poured into a tin canister. (6) Take Burgundy pitch, 2 lb.; rosin 2 lb.; yellow wax, 2 oz.; dried whiting, 2 lb.;

melt and mix. (7) Black rosin, ¼ lb.; yellow wax, 1 oz.; melt together, and pour into a tin canister. When wanted for use, chip out as much as will cover the chuck to $\frac{1}{16}$th of an inch, spread it over the surface in small pieces, mixing it with an eighth of its bulk of gutta-percha in thin slices; then heat an iron to a dull red heat, and hold it over the chuck till the mixture and gutta are melted and liquid; cool the iron a little and with it stir the cement until it is homogeneous; chuck the work, lay on a weight to enforce contact, leave it at rest for half an hour, when it will be ready for the lathe.

Tyre.—(1) Crude rubber, 4 parts; Venetian red, 2 parts; resin, 2 parts; tallow, 1 part. Melt the rubber over the fire, add the resin and tallow and, lastly, the Venetian red. (2) Gutta-percha, 8 parts; shellac, 8 parts; sulphur, 1 part; red-lead, 1 part. Melt the gutta-percha and shellac together, then add the red-lead and sulphur. Both the foregoing have to be heated for use. The following is a semi-fluid cement, resembling some of the rubber cements already described. Crude rubber, 24 parts; resin, 7 parts; shellac, 5 parts. Add sufficient bisulphide of carbon to dissolve into a thick gummy mass.

Waterproof.—(1) Glue to which bichromate of potash has been added, and which has afterwards been exposed to strong sunlight becomes insoluble. The proportions are not very well ascertained, but about 1 part of the bichromate dissolved in water and added to a solution of 6 parts of solid glue answers very well. (2) It is said by the 'British Journal of Photography' that the following recipe gives excellent results: Take alcohol, 1 pint; sandarac, 1 oz.; mastic, 1 oz.; common white turpentine, 1 oz.; glue and isinglass, sufficient; water, sufficient. Dissolve the two resins—sandarac and mastic—in the spirit, and then add the turpentine to the solution. Make some very strong glue, and add to it a good pinch of isinglass. Now heat the alcoholic varnish until the liquid begins to boil, then very slowly stir in the warm glue. The amount of the liquid glue to be added is determined by noting the point at which, after thorough mixture, a magma or thin paste is formed capable of being easily strained through cloth. When required for use, the strained mixture is to be warmed, and applied like ordinary glue to the articles to be united. A strong junction is effected, which is not destroyed by cold water and only after a comparatively considerable time by hot water or ordinary saline solutions. (3) Glue, 1 part; skimmed milk, 8. Melt and evaporate in a water bath to the consistence of strong glue. This cement cannot be called waterproof but it resists the action of water better than common glue. (4) Melt common glue with as little water as possible, add ¼ of boiled linseed-oil, dropping it gently into the glue which is to be stirred all the time. (5) A cold solution of 1 part green copperas in 3 of water is extremely effective in rendering cement and lime plaster proof against the weather. Cement manufactures are put into the solution for 24 hours, and then, coloured greenish black by the oxidulated iron hydrate which has been formed, dried in the air. The absorbed solution of copperas has been decomposed in the cement, and the combination of hydrated peroxide of iron formed is stated not only to render the cement denser and harder, but also, as it is not affected by the weather, to impart to it greater resistance. The weight of the cement is increased by 10 per cent., without any change in form. Cement plaster is protected against the effects of the weather by repeated applications of the copperas solution. If, after the 4th application, the cement does not turn a dark greenish-black, it is a sign that the surface has become saturated with the iron combination. After drying, a coating is formed on the cement of an ochre-like colour, which cannot be washed off with water, and which will take water-colours. If cement plaster thus prepared is to be permanently painted with oil colours—which, as is well known, peel off ordinary cement —two applications of 5 per cent. soap water are sufficient to render it waterproof, and, after drying and rubbing with a cloth, as shiny as oil colour, so that one coating of the latter may be saved. In order to protect cement manufacture prepared with copperas against acids, alkalies, and the influence of the weather, a layer of a heated mixture of equal parts of ordinary paraffin and paraffin oil, or petroleum, is sufficient, which is obtained by immersing the heated cement articles in it for a few minutes. This cheap copperas solution may also be used for old or new lime plaster; old lime plaster must, however, first be freed from loose particles of colour by washing off. It is not advisable to mix the cement and sand at once with the copperas solution, as cement thus prepared cracks after drying. ('Builder.') (7) Tar, 1 part; tallow, 1; fine brickdust, 1; the tar is warmed over a very gentle fire; the tallow is added, then the brickdust, and the whole is thoroughly mixed. It must be applied while hot. (8) Good grey clay, 4 parts; black oxide of manganese, 6; limestone, reduced to powder by sprinkling it with water, 90; mixed, calcined, and powdered. (9) Manganese iron ore, 15 parts; lime, 85; calcined and powdered. Both (8) and (9) require to be mixed with a little sand for use; thrown into water, they harden rapidly. (10) Fine, clean sand, 1 cwt.; powdered quicklime, 28 lb.; bone ash, 14 lb. Beaten up with water for use. (11) Quicklime, 5 parts; fresh cheese, 6; water, 1. The lime is slaked by sprinkling with the water; thereupon it is passed through a sieve, and the fresh cheese is added. The latter is prepared by curdling milk with a little vinegar, and removing the whey. The cement thus formed is very strong; but it requires to be applied immediately, as it sets very quickly. (12) Fresh curd, as before, 1 part; quicklime, 1; Roman cement, 3. Used for joining stone, metals, wood, etc. (13) A paste composed of hydraulic lime and soluble glass. (14) 1 glue, 1 black resin, ¼ red ochre, mixed with least possible quantity of water. (15) 4 glue, 1 boiled oil by weight, 1 oxide of iron. (16) Mix a handful of quicklime with 4 oz. linseed-oil, thoroughly lixiviate the mixture, boil it to a good thickness, and spread it on tin plates in the shade. It will become very hard, but it can be dissolved over a fire, like common glue, and it is then fit for use.

Wollaston's.—This is a very valuable cement for large objects, such as shells, fossils, etc.: Beeswax, 1 oz.; resin, 4 oz.; powdered plaster-of-Paris, 5 oz. Melt together. To use, warm the edges of the specimen, and use the cement warm.

Wood.—(1) A mixture of lime, clay, and iron oxide, separately calcined, and reduced to fine powder, then intimately mixed, kept in a close vessel, and made up with the requisite quantity of water when wanted. (2) The following cement will be as hard as stone when dry, and will adhere firmly to wood. Melt 1 oz. resin and 1 oz. of pure yellow wax in an iron pan, and thoroughly stir in 1 oz. of Venetian red, until a perfect mixture is formed. Use while hot. (3) For cracks in wood. (*a*) Slaked lime, 1 part; rye meal, 2 parts; made into a paste with a sufficient quantity of linseed-oil; (*b*) Glue, 1 part, dissolved in water, 16 parts; when almost cold, sawdust and prepared chalk are stirred in to the required consistence; (*c*) Oil varnish, thickened with a mixture of equal parts white lead, red lead, litharge and chalk.

Zeiodelite.—This cement consists of 19 parts of sulphur, and 42 of powdered glass or earthenware, mixed thoroughly together by heating the sulphur. It may be used instead of hydraulic cement for uniting stones or bricks, and for cementing iron rods into holes cut in stone.

Zinc.—A cement for zinc is made

by mixing whiting and zinc dust with water-glass.

Cement for Repairing Defective Zinc Ornaments.—By intimately stirring together to a thick plastic mass a solution of soda water-glass of 33° B. with fine whiting and adding zinc dust (zinc grey or tutty), a grey mass is obtained which hardens in 6 to 8 hours, and becomes extraordinarily solid. By polishing it, after hardening, with an agate it acquires the lustrous white colour of metallic zinc. It is especially suitable for repairing zinc ornaments and vessels, but it also adheres firmly to stone and wood as well as to metals and glass. It can be used as a paint.

A zinc composition for repairing stonework.—This is made from 2 parts by weight of oxide of zinc, 2 of crushed limestone, and 1 of crushed grit mixed and ground together into a powder. To this is added a liquid consisting of a saturated solution of zinc chloride, to which is added an amount of ammonium chloride equal to ⅛ the weight of the zinc contained in the chloride of zinc. The liquid is then diluted with ⅔ its bulk of water, and 1 lb. of the powder is mixed with 2¼ pints of the above liquid.

* * *

CHARCOAL.

THE simplest form of kiln for charcoal burning is that shown by Fig. 76. It is formed by sticking one or more poles in the ground separated by wedges; the wood being cut to uniform lengths is stacked round this with an inclination to the centre, with a top layer of pieces laid horizontally, the interstices being carefully packed up with smaller pieces. A small tunnel is left at the bottom to facilitate the lighting, and the whole is then covered with a thick layer of clay or turfs carefully laid so as to be as air-tight as possible. A small pile of dry shavings or sticks is put at the bottom of the chimney formed by the poles with which to ignite the pile. On first lighting a good draught is required to make a good heat, to drive off the moisture from the wood, and give the fire a good start, and then the opening must be closed over to limit the air supply so that the combustion shall be as slow as possible, and constant attention is also required to keep the covering intact as the wood burns away.

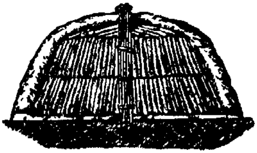

FIG 76.

As the distillation progresses the water is evaporated, and the heavy smoke turns to a light vapour as the tarry matters are driven off; when the smoke becomes a pale blue in colour, it is evidence that the process is nearing completion, and all openings must be tightly closed to stop the combustion of the charcoal itself, and to enable the whole mass to cool off.

When this stage is reached the outside cover is removed, and any glowing charcoal must be quenched with water. This process is somewhat wasteful owing to the large proportion of half-burnt ends of wood that remain, and to the fact that charcoal quenched with water easily breaks up, but it is so simple that it is almost universally used where no outlay is possible for a better apparatus.

CHIMNEY CLEANER.

CHEMICAL.

THE chemical chimney cleaner is a compound in powdered form, made up in packets, to put on a hot fire, when it evolves gases which have the effect of carrying off a good deal of the soot in a chimney. The same compound has also been sold to improve the heating of ovens, but is only effective of course in ridding the flues of some of the soot. The instructions for use are to make a hot fire, then put the packet on and put a blower up in front of the fire (if it is an open grate) and in a few minutes the contents of the packet have effected their purpose.

(1) Parts by weight: blue stone, 7; coarse salt, 6; muriate of ammonia, 8; saltpetre, 5; fine sand, 2; coke dust, 2. Well mix. Can be coloured with any inert material, such as red ochre, if desired.

(2) Parts by weight: chloride of sodium, 7; potassium nitrate, 4; flour sulphur; cuprous sulphate, 7; muriate of ammonia, 8; colour as (1) if desired.

CHIMNEYS.

THEIR ACTION AND CAUSES OF FAILURE.

(*See* also RANGE AND GRATE FIXING.)

Draught.—Before any intelligible account can be given as to the action of chimneys (efficient or non-efficient), it becomes necessary to explain as clearly as possible the phenomenon of "draught," without which chimneys would be of little service for any of the uses to which they are put. It is understood, of course, that by the word "draught" is meant the unceasing up-flow of air that will be found passing through chimneys, entering at the bottom aperture and escaping at the chimney-top. About the only occasion upon which this steady up-flow of air becomes irregular is when a chimney suffers with "down-draught," a trouble that will be referred to presently. At almost all other times the up-draught is constant, only varying as regards its strength, for even new brick chimneys, or those that may have been disused for a long period, are commonly found to have a constant though somewhat feeble draught in them.

The actual cause of draught in chimneys, the regular ascending current, is due to the fact that cold air is heavier than that which is hot.

The action is as follows: Supposing a stove exists at the bottom of a chimney, as Fig. 77. When the fire is lighted, the air within the stove becomes rarefied by the heat, that is, it is made or rendered lighter than it was, owing to its particles having become expanded by the warmth they have absorbed. Immediately they thus become lightened, they are displaced by the superior weight of the cold particles around them, and this displacement causes them to take an upward direction.

The warm air rises up into the chimney, and the cold air which has entered to take its place, gets warmed, and rises also, and so it goes on. The action is continuous, and exceedingly rapid, as can be judged by holding a lighted taper where the air enters the stove. The direction of the flame of the taper will show what a keen inrush or stream of air is entering the aperture.

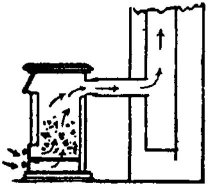

FIG. 77.

In addition to air that may be warmed, and so caused to make an up-draught in the chimney, there are the hot products of combustion. The air which has actually passed through the burning mass of fuel, undergoes a chemical change, and becomes a gas with a different name; but it still remains lighter than the cold outer air, and consequently acts in the way described. With stoves very little air passes through without undergoing this change, or becoming very highly heated, and the result is a much stronger and more powerful draught in the chimney than we get with an open grate. With this latter article, the open mouth of the chimney, whether the grate be an old or new pattern, permits of a deal of air passing in which is barely warmed, and this tends to retard, or at any rate interfere with the draught.

It is peculiar to note what a length of time a brick chimney will retain sufficient warmth to induce a draught in it. Chimneys that have not been in use for months are sometimes found to have a steady up-current of air in them, due to the brickwork still being able to impart sufficient warmth to the air in contact, to render it lighter. In perfectly new chimneys a feeble up-draught is sometimes observable, caused by the mere fact of the air inside the building being a degree or two warmer than that which is without.

To illustrate the rapid action induced amongst the particles of a fluid by a very little heat, take a glass flask or jar of small size, holding say a pint, and nearly fill this with cold water. Into this water stir a small quantity of hard-wood dust (fine sawdust of mahogany will do), and then suspend the jar so that a lamp can be placed under, and the results noted. A small paraffin or benzoline lamp is better than a spirit-lamp for this purpose, as the flame can be turned down low, and we can see what a very little heat will do. If we place a lamp under, we shall find that, although the heat which comes from the lamp chimney is far from great, the particles of dust will almost instantly set up a motion, and the motion of some of the ascending particles will be exceedingly rapid. By watching the dust particles we are able to tell what is happening with the particles of the liquid, for it is the movement of these latter that causes the solid particles to take the direction they do.

If we take the average open range (and there are very many still existing in large residences in London as well as in the country), we find that there is a 24-inch to 28-inch space between the top fire-bar and the chimney breast above it. If this space is left open, the smoke from the fire will show great reluctance to pass up the chimney, and in quite 80 per cent. of such cases some of the smoke will ooze out into the kitchen, and the range is said to smoke. The remedy for this state of things is the introduction of a blower, a sheet of metal placed so as to reduce the space just referred to, and the inflowing air is caused to come more within the influence of the fire. This is effectual for the simple reason that it prevents, or at least reduces, the free passage into the chimney of air that is absolutely cold.

An instance once came to the writer's notice in which one of these old-pattern ranges had to be retained in the kitchen, although it was noted for its rarely ceasing its (till then) incurable habit of smoking. An ordinary blower was of no avail—that is to say, it did not wholly remedy matters, although it effected a little improvement. An effectual cure was made in this case with a specially made blower, which reached down to the level of the top fire-bar as Fig. 78. This had its lower part in sections which could be raised to admit of the introduction or withdrawal of the cooking vessels. It will be seen that by this arrangement the open range was almost converted into a close-fire kitchener, so far as its shutting out cold air from the chimney was concerned.

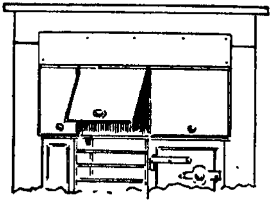

FIG. 78.

With dog-grates the smoke trouble, when it occurs, is caused by precisely the same conditions as with the open range. These grates are usually fixed in a roomy opening which is tiled round, and the result, so far as appearance is concerned, could not be better. The spaciousness of the opening is, however, what ruins the efficient working of the chimney and the grate, by reason of the abundant presence and inflow of cold air as just lately described.

Blowers are sometimes applied to these openings, to obviate or cure the sluggish action of the draught in carrying the smoke away. Either a piece of bevelled plate, or ordinary sheet in a brass frame, or coloured leaded glass as in Fig. 79, would look and act excellently. This would overcome the smoking, assuming it proceeded from the cause under discussion.

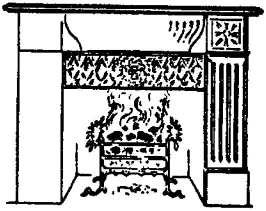

FIG. 79.

Pipe Chimneys.—No one can deny that for certain purposes a great convenience is effected by the use of sheet-iron pipe for the conveyance of smoke from a stove, or from a portable cooking-range, etc., in instances where a brick chimney is not conveniently near. It may be that the pipe is carried the whole way as far as is necessary for it to constitute a chimney of itself; but more often this pipe is used to connect the stove with some existing brick chimney not far away; in the same or next room, perhaps.

It is considered a very simple matter to fix up a stove in this way; we have to provide a suitable non-inflammable base, fit the pipe on the nozzle of the stove and carry it to the chimney-breast, there inserting it in a hole prepared to receive it. It is important that the pipe be large enough, and numbers of failures have been due to error in this direction.

Stoves that are always closed—that is to say, cannot have the fire opened except for feeding or stoking—can generally be worked successfully with a smaller-sized chimney (whether pipe or brick) than open grates, but of course a man should never fall into the error of making his chimney of less size than the nozzle provided on the stove by the maker. With stoves, the whole of the air passing into the chimney has to pass through the fire and become heated and rarefied. This by itself is sufficient to bring about a keen draught. Further than this, there is a total exclusion of cold air, and so the chimney itself is not chilled; and altogether, we as a rule get a draught with a stove that needs to be checked and controlled carefully by means of dampers. Now, the keener the draught the less size the chimney may be to work effectively. This explains why stoves may have smaller pipes, when of the close description, than any form of open grate or convertible arrangement, which permits air to pass into the chimney without being heated.

With any form of stove that is of a portable character, fixed out in a room, but works with an open fire (under the conditions of an open grate), the pipe that may be used with it should never be less than 9 in., and even larger than this is necessary, if the stove is actually of large size. They really should have pipes equal in size to the chimneys provided by a builder when he builds a house—viz., 9 by 9, or 14 by 9 square.

Makers might well make the nozzles larger; it would be practically impossible to make them too large, and, up to a certain point, the stoves would be decidedly benefited. If an instance occurred in which the pipe had to be carried conspicuously, it would then be time enough to reduce the size to the least limit by means of a reducing piece.

It has to be acknowledged that the unsightliness of the pipe-flue increases in proportion with its increase in size; but, strange to say, no one, at least very few people, think of overcoming the ill-appearance of the pipe by decorating it. A 9-in. pipe, coloured to match its surroundings, has a decidedly better appearance than a 6-in. pipe left its natural black colour, yet everyone seeks to reduce the evil by using a smaller pipe, much to the detriment of the stove.

To decorate these pipes, only water colours or washes can be used—merely the colouring matter, with water, and a little size as a fixative. If a little lime-white be made, and coloured with burnt umber, this will give the pipe as good an appearance as could be desired, and the heat will not affect it nor cause it to peel. The appearance can be further improved by ornamental stencilled bands round the pipe here and there in a darker shade. Of course, a brown shade will not suit all surroundings. It would not agree if the general decorations were blue, but the white wash can be tinted just as may be required. In the latter case a light slate colour might be applicable. A skilled decorator could probably choose his colour so that the pipe in some situations, although in full view, would scarcely be noticed at all.

If we fix a stove in a room, and carry a pipe from it into the chimney breast some few feet away, as Fig. 80, we shall get bad results if the pipe joints are not sound by reason of cold air passing in as indicated by the arrows. The ill results in this instance are two-fold, for we not only get the cooling influence of the air passing in at these fissures, but the draught which we depend upon to pass through or near the fire in the stove, only does so to a lessened extent with proportionately lessened good results.

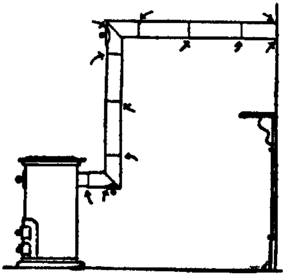

FIG. 80.

It matters not how small the crevices may be, they should be tightly stopped. Occasionally a chimney may be of such a height or character that its draught is strong enough to ignore small leakages; that is to say, the draught is of such strength that a leakage merely takes a small proportion of it, and there is still abundantly sufficient passing through the fire to keep it burning properly. A chimney of this efficiency, though, is no excuse for bad pipe joints. Bad joints are evidence of bad workmanship or carelessness.

It is hardly possible to get air-tight joints in iron pipes without the aid of some packing material, and for this purpose nothing excels common glazier's putty. It is necessary to first paint the surfaces before the putty is applied. This insures the putty adhering to the metal surfaces. A very imperfect joint is made without paint. The peculiarity of putty is that it hardens with heat, and after a little time the joint will not only remain sound, but it will be found firm enough to require a genuine effort to unmake it.

Sometimes a portable form of cooking-range is fixed standing out in a room or kitchen. This is done for various reasons: for convenience, or commonly is to avoid interfering with a large existing range. Portable ranges are frequently fixed in front of existing ranges with a pipe-flue carried into the chimney. Now, when a range is used with a pipe-flue, the question of joints is a very important one. With almost any form of portable range the passage that the air or draught has to take from the fire opening to the chimney is so much the reverse of straight or direct that a certain resistance is caused, and a much stronger draught is needed than with stoves with the straight passage through them.

It is probably known to everyone that the direction the draught has to follow in passing through a close fire-range is as indicated by the arrows in Fig. 81. This means that, in the first place, the air has to travel in directions quite contrary to that which it is natural to follow. It was explained earlier that the action brought about by subjecting air to heat causes the warmed air to take a directly ascending direction. We, however, in this cooking-range require the draught (around the oven) to first pass along a horizontal flue, then *descend*, then travel horizontally again before it can ascend in the slightest degree. In addition to this, these flue-ways are invariably narrow, and this, with the abrupt angles, brings about considerable resistance to the passage of the air and the smoke it conveys. It must also be understood that a sluggish draught will never do for a close fire-range; it may possible work it for one day, but the deposit of soot is so abundant from the dull-burning fire that nothing can be done with the range unless the flues are cleaned daily, and even with this care the range is a very limited success.

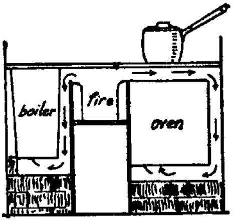

FIG. 81.

It is always necessary, when fitting up stoves and ranges in this way, to see that the joints in these articles themselves are sound. Range-fitters (the men who actually fit the castings together) are so apt to think that all ranges are set in openings with brickwork round them (which goes to stop up all leaky joints), that a deal of carelessness is often introduced. It is also very necessary to see that where the pipe fits on the nozzle of the stove, and also where it enters the chimney breast, are made air-tight. In other words, see that all the air which enters the chimney first passes through the fire. This is strictly necessary. Many a range has been a temporary failure wholly because one of its soot-doors has been left out of place or lost. The failure has been remedied the instant the door has been put in its place, and the opening thus stopped.

This brings to mind the third possible cause of failure in fixing stoves or ranges in this way. This error is in omitting to stop or close the brick chimney off below where the pipe enters it. When we carry a pipe into an existing brick chimney through the chimney breast, it follows that some form of grate or range is at the bottom of this chimney, or it may be that the grate or range has been removed, and a bare opening exists. Whichever may be the case, it is absolutely necessary that all passage of air into the chimney in this direction be stopped. If it is an old-fashioned register grate that is there, the register flap can be tied down, and if necessary jointed with putty (the register can be opened when the chimney has to be swept). If it is an old open range then the open mouth of the chimney over the range must be closed across in an air-tight manner with a sheet of iron. To prevent the removal of this sheet every time the chimney is swept, a well-fitting door must be provided in it for the sweep to operate through. In any case, whatever opening exists at the bottom must be stopped. If a close-fire range exists at the bottom of the chimney, and is not used, then see that the dampers are pushed in tightly, and that no doors are left off, or openings exist.

When it is possible or convenient, it is a good plan to stop the chimney just below where the pipe enters, and only leaving room for a soot door and frame for the removal of soot, as Fig. 82. It may be thought that the omission of some provision to close the chimney at the base is very unusual, but it is far from being the case. Numbers of failures have been due to this cause, and if it is a portable range that has been fixed, it is a failure of a very pronounced character when this oversight occurs. It is so much easier for air to pass up this clear and directly-ascending passage, than it is to pass through a fire and a maze of flues, that the range is almost ignored altogether.

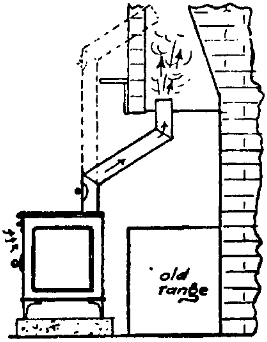

FIG. 82.

A fault, that is pronounced with iron pipe flues, its rapid loss of heat, or the cooling influence the air has upon it when outside the building, can be obviated very successfully by a covering of some compound that is very poor in conducting heat; a non-conductor as it is commonly called. To make the pipe approach a brick chimney in effectiveness, the covering must be of a nature to absorb and hold heat, as well as to prevent its ready transference through its substance or thickness. Silicate cotton is an exceedingly good material in this respect, but it is a little difficult of application. There are other patented compounds of a cement nature that can be applied very well, one of these being Leroy's composition, a material largely used for covering steam boilers, etc., and is well spoken of. This remedy, however, is seldom resorted to, as the temporary nature of the work does not warrant it, and if this expense can be gone to, then, as a rule, a brick chimney may as well be put up. The cost would be but very little greater.

If it is required to erect a pipe-chimney outside a house, and which is intended to be of a permanent character, then cast-iron pipe or pipe of earthenware material is used. The cast pipe will last an endless period, as its substance, if of good quality, will be $\frac{5}{16}$ in. or $\frac{3}{8}$ in., and the joints are of a sound and lasting kind. This pipe requires supporting in a thoroughly substantial manner. Earthenware pipe, when used, is the kind that is made for drainage purposes, glazed inside and out. This latter pipe possesses the advantage of nearly approaching brickwork in its composition; in fact, the material of the pipe may be said to be identical with that which constitutes a brick. Earthenware pipes make splendid chimneys but they are somewhat expensive, particularly in the means that have to be adopted to support them. Brick chimneys are now being built with glazed pipe linings, and the result is very satisfactory.

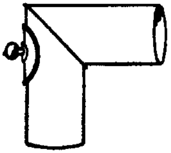

FIG. 83.

With every kind of pipe-chimney there should be provision made for sweeping. This is effected by means of doors or plugs at the elbows, as Fig. 83, or wherever the pipe takes an abrupt turn. Even if the angle is very obtuse, it should never be arranged for the sweep's brush and rods to push past it. The pipe itself may not be injured by so doing: but there is a tolerable certainty that the joints will be strained after it has happened a few times. The reader will also understand how necessary it is that all doors and such openings in pipes be carefully made, so that when closed no in-leakage of air occurs.

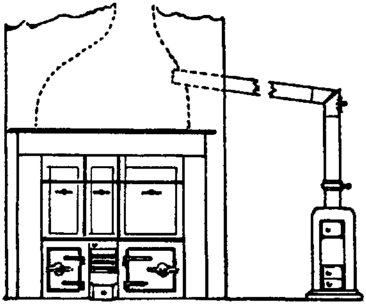

FIG. 84.

If we have two stoves into one chimney, as Fig. 84, for instance, and both fires are alight, there will be a draught passing through each into the main chimney. There is nothing objectionable in this provided each has its fire alight, and it is understood that both are *close* stoves (or close fire kitchen ranges). Each will furnish and contribute its supply of heated air and also the hot gases, which go to make the draught themselves, and which also furnish heat to the brickwork in the way that has been explained. Now if we extinguish the fire in one of the appliances, what is the result? It is precisely the same as having a large sized hole in an ordinary chimney by which cold air can pass directly in, and effect all its ill and troublesome results. It will be seen that when we put out the fire in one stove we do not put a stop to the pulling power of the chimney, and consequently cold air will be drawn through this particular stove into the chimney, and seriously affect the activity of the one that is working. The difference is all brought about by having cold air passing into the chimney instead of heated air and hot gases.

The method adopted to prevent this trouble is to provide a well-fitting damper to each pipe or branch chimney. This should be placed somewhere near the stoves where it can be got at easily. When a stove is not in use the damper is closed; but it will be understood that it should be one which when closed will really prevent air passing through. A sliding damper is best. Those dampers commonly used with pipe flues, and which are merely a disc of metal within the pipe and operated by a handle outside, are not satisfactory. They cannot be made to fit the pipe tightly—that is in an air-tight manner, and unless they are most accurately balanced they will not remain as they are set. The draught itself will move them unless they are fitted very precisely.

The other particular points to be considered when working two stoves into one chimney is firstly to see that the chimney itself is of full size. A 9 by 9 chimney will not do this unless it is a high one, with (consequently) a very effective draught, or unless the stoves are only of moderate size. The pipes (or branch chimneys) which connect the stove with the main chimney must both be of full size, the same as if one stove only was connected. The joints in the pipes must be sound, and all the other points already explained have to be thought out.

An unusual experience that occurred to the writer in connection with pipe-chimneys was an instance in which a portable cooking-range of large size was placed in a building for temporary cooking purposes. It was fitted up with a pipe chimney of full height, and correctly erected in all other ways except that the pipe was only 7 in. diameter. This sized pipe was found insufficient, for although the range did manage to cook when the pipe was quite clean, it worked very sluggishly, and this brought about a rapid accumulation of soot. Of course, as the soot accumulated in the pipe so the passage-way became reduced, and altogether it became necessary for something to be done.

Upon examination nothing could be found to account for the inefficient results except the smallness of the pipe, and it was decided that a larger one was needed, and it was suggested that it should be of double the area or size of the existing one. This alteration was left for the owners of the range to do, as they had men and abundance of the necessary stores, but this is where the peculiar part of the work occurred.

It was discovered that there was plenty of 7-in. pipe ready made, but none larger, and it occurred to the engineer, that as a pipe of double the area of a 7-in. pipe was needed, why not use two pipes of this size, instead of making a new pipe for this temporary purpose. This idea was acted upon. The existing 7-in. pipe was disconnected at the range, a short length of larger pipe made with a junction-piece, and placed at that point and a second pipe run up as Fig. 85. (This illustration shows straight

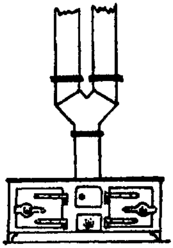

FIG. 85.

pipes for the sake of making the explanation clear. They were not exactly straight, but they ran side by side all the way.)

The result of this arrangement was a most pronounced failure, and until the cause was discovered it was a most difficult failure to account for. All the usual causes were searched for, such as leakages, openings, bad joints, etc., without avail, and the pipes were found to be quite clear. Ultimately it was noticed that what smoke did pass into the chimney only issed from one pipe, and the idea was entertained that the second pipe, for some reason, was refusing to act, and the work was being done by one pipe as before. A moment's thought, however, showed that this theory did not quite meet the case, for the range was working in a much worse manner than when it had one pipe only, and if it was now a case of one pipe being actively working, and the other idle, the results ought at least to have been as good as before, which, however they were not by any means.

It was ultimately discovered that what up-draught existed in one pipe was supplied from the other, The direction of the air or draught in the pipes was as indicated by the arrows in Fig. 86. There was a certain amount of warmed air and gases passing up from the range, but only what would naturally rise by the fact that they were warm, not sufficient by any means to work the range. The really active force of the draught was busy in the pipes, down one and up the other, quite ignoring the range below.

A very little consideration shows that this is a very natural result. Wherever two chimneys exist, it matters not how exactly alike they may be built, one will work differently to the other. In this case one chimney was a little more effective than the other, and instead of drawing its air through a mass of fuel, and through a ramification of oven flues, etc., it naturally preferred to have its supply from the free and open source that the other pipe constituted. It has been explained that the rush of air into a chimney will take place equally through every opening it can find, only showing a preference when one opening is more free from obstruction than another. In this case results were obtained practically the same as providing a simple opening (instead of another pipe) at the junction piece, as Fig. 87.

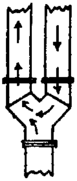

FIG. 86.

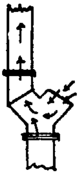

FIG. 87.

It is somewhat strange, but instances have been known where twin chimneys something like this have worked well; but such a result could in no way be relied upon. It should never be attempted, for should results be bad there is no remedying the matter, except by putting a single full-sized chimney.

Sometimes two brick chimneys become joined in this way unintentionally, and cause a deal of trouble. It occurs through the sweep's tools or some other cause, dislodging some of the brickwork which forms the partition between chimneys when they are run up side by side. The displacement of a single brick is sufficient. A fault of this sort is usually very difficult to discover, as it probably means opening the chimney at various points, until the defect is found. Sometimes a workman has become impressed with the idea that this fault exists in a chimney, and he cuts away and does infinite damage, only to discover that the defect does not exist. This should not occur if ordinary care is used in testing the chimney to find the cause of its inefficiency.

The method that can be adopted with a prospect of discovering the fault with certainty is to make a fire in the stove or range that is giving the trouble, and stand by it and watch the results while an assistant places a sack over the top of this particular chimney and afterwards over the chimney-top next to it. Previous to doing this, the chimney-tops should be watched to see the action of the smoke coming from them.

A usual and commonly troublesome phenomenon in connection with sheet-iron pipe chimneys, is the trickling of water down inside them. Sometimes the quantity is really large, and provision has to be made for its escape. This trouble is seldom noticeable with indoor pipes, or with any that are fixed in warm situations. With outside pipes it is more noticeable, particularly if the pipe is a flue to a gas-stove and has no soot within it. When soot is present, its poor heat-conducting properties bring about results somewhat approaching those obtained by covering the pipe with material to conserve its heat. When no rapid cooling influence is manifested, the water difficulty does not present itself.

It is not so generally known as might be that of the different products or results of combustion water is one, and that it is formed very freely indeed. We never notice it with our ordinary grates and stoves, which are worked with brick chimneys, and which are always warm. The water is formed in exceedingly minute particles, so as only to form an extremely thin vapour, and this passes up and out of the chimney with the smoke, as the warmth of the chimney does not permit it to condense.

When the smoke and products of combustion from coal or gas are carried up into a pipe chimney outside a house, the cooling influence of the air through the thin metal causes the water vapour to be condensed, in the same way that steam would be; and the instant this takes place the water ceases to rise with the other products, and falls or trickles down the pipe. Sometimes the quantity of water-vapour and its condensation are such that a small but continuous stream passes down the pipe.

When a pipe gets coated internally with soot, this condensation becomes less, and commonly ceases altogether. The soot is a poor conductor of heat, and the contents of the chimney, the gases and water vapour do not get cooled, and the results are (though in a very limited way) more like those obtained with a brick chimney.

The pipe chimneys attached to gas stoves (of all descriptions) suffer most with the water difficulty in question. With these the pipes always remain clean, and any cooling influence there may be acts upon them very quickly and surely, We may also look for a little more water vapour to result from the combustion of gas than from coal, as the former has hydrogen so abundantly and so free in its constitution, much more so than with coal.

Another feature in connection with pipe chimneys which should always have consideration if coal fuel is to be used is the soot deposit, which occurs more rapidly in these than in brick chimneys owing to the greater cooling effect on the iron pipe of the outside air.

The provision of sweeping-doors at every angle, as was recommended, is particularly necessary for the removal of fallen soot—soot that falls down the vertical pipes and in other ways collects at these points. The falling of soot occurs much more frequently and readily from the smooth surfaces of pipes than from brickwork.

Down-Draught.—It must first be explained that down-draught is of two characters. First, a down-blow in the chimney of a gusty character, which at one moment is sending smoke, and possibly flame, directly into the room; then the next moment the chimney is calm, and possibly working normally. Intermittent in its action, in an irregular way. Secondly, a down-draught of a very regular kind, one that acts for all the world as if the chimney wanted to show how permanent and steady its draught was; but, unfortunately, the draught takes a descending instead of an ascending direction.

The first of these manifestations is invariably noticeable at certain times when the wind is in particular quarters, blowing from what may be termed objectionable directions; but, of course, there is no one direction from which the wind blows more objectionable to chimneys than another, and in some of these troublesome cases it may be the west wind that causes the down-draught, and in others it is when the wind is from the east or some other quarter. Now, in practically all these cases the trouble is brought about by the chimney being of insufficient height, or of such a height that some adjacent building or object is higher, and deflects the wind so that it interferes with the ordinary up-draught of the chimney in question.

To insure any real reliance in the effective working of a chimney, it must not only be as high as its surroundings, but in nearly every case it should be higher by at least 6 ft. Take, for example, the shape of the roofs on most of our suburban properties—they are ridge-shaped. If a chimney terminates level with this ridge, or even a foot above it, there is the probability of its being troublesome, notwithstanding the chimney itself is several feet from the ridge in question. With this particular class of roof, it is not always the case that chimneys terminating less than 6 ft. above the roof have been a source of annoyance, as many other things govern the results; but many instances have come to the writer's notice, and been remedied by being heightened either with brickwork or a tall pot. In these cases the trouble has arisen chiefly when the wind has blown so that it passed over the roof before reaching the chimney, and as it passed the ridge, it had necessarily to pursue a downward direction more or less abrupt, and its force was thus directed into the open chimney-top, as Fig. 88. With an example of this kind it will be seen that any variation in the direction of the wind would bring about a varied degree of annoyance; and so, also, as the wind was strong or the reverse, the results would be greater or less accordingly.

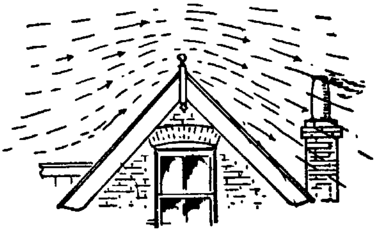
FIG. 88.

A state of things which, it will be understood, brings about this down-draught, but which is more difficult to deal with, is when the chimney is part of an addition or wing to a house, and which is considerably lower than the main building. There are thousands of such cases amongst the large residences in the west of London, and a really great number of suburban houses are planned with what is termed a back addition. These additions are almost always lower than the general building, and the chimney tops often terminate from 20 ft. to 40 ft. below the roof of the main structure which is near beside them. With these the action is much more pronounced than with the ridge-roof example just given, for when the wind beats against a wall and has no ready or free means of escaping, it produces a very violent motion, swirling about, and, it would seem, blowing in ever so many directions at once: and where money is not a great object, there have been instances of people trying every description of cowl and wind-guard they could purchase to try and make such chimneys effective, but without avail, or with a very limited sort of success at the best.

In cases such as this a cure could be certainly effected by carrying and continuing the chimney up to above the main building, terminating it level with the other and effective chimneys that are up there, and which work the different fires in that part of the house without the trouble in question. This, however, is where the bother arises. The chimney to be cured may be 30 ft. or more from the wall, and supposing it were carried across to this point, it would, perhaps, have to go up a considerable distance, and although quite possible, it would be an expensive matter, and this leads people to trust to the statements that appear in the circulars of windguard-makers. If any readers want to make interesting little experiments respecting this subject, let them just get a short length of glass tube, and put very small pieces of cotton wool in it. The wool should be little, loose, fluffy pieces that will move with a little draught like smoke. It will be found in the very first place that a current of air across the top of the tube will induce a rapid up-draught in it without the assistance of fire or heated gases, and directly air passes sharply across the upper end, the cotton wool will fly up and out at a speed too quick for the eye to follow. By placing different objects around the tube, many peculiar results can be noted. Enough will be learnt to show that a chimney top should be clear above everything, and nothing ought to project above it anywhere, not even the chimney-pot next to it: they should be level. When chimneys are terminated in brickwork at the extreme top, a brick out of place, or even irregularly laid, may very possibly give pronounced ill results.

The other form of down-draught—viz., that which is more constant or steady than the last, proceeds from an entirely different cause, and many are the strange ideas workmen entertain in regard to it. To those who know the cause, the efforts to cure it on the part of those who are ignorant are always entertaining. This is a form of down-draught that no cowl and no raising of the chimney will cure; the latter, however, might possibly alter the effect.

The cause of this trouble has been christened "siphonage"; but this is scarcely a correct term. The real action is that of air descending one chimney to provide that which is needed to maintain the up-current in another. In other words, there are two chimneys, either in one room, or they may be in two adjacent rooms. Air is needed to make the up-draught in these but it cannot be obtained; consequently one chimney, the stronger we may assume, by its up-draught, causes the necessary inflow of air to come down the other. To some extent it is similar to the action explained above, when it was tried to work one stove with two chimneys.

Everyone knows that the up-draught in a chimney is nothing more nor less than a current of air, and a moment's thought is sufficient to show that this unceasing up-flow represents a considerable volume. Now, where does this air proceed from? From the room in which the stove is, of course; but where does it proceed from to get into the room? The chimney does not exhaust the room of air. In fact, the chimney would not act unless air entered the room just as fast as the chimney withdrew it. It will be found that the primary entrance for air into a house is the outer doors, front and back, and through the crevices of these (when they are not open) comes all the air for respiration, combustion, and draughts for chimneys. This is supposing some special system or mode of inlet ventilation is not provided, and it quite usually is not.

The crevices round windows provide a little, but it is a very small quantity, as these are usually well-fitting, especially in good houses.

Having explained this much, an explanation of an instance where this trouble occurred will make the rest easily understood. A complaint came from a house in the suburbs of London that a room had a fireplace in it that could not be used owing to the persistent down-draught in the chimney, and the room itself and the one adjoining were rendered almost unbearable by the very strong odour of soot. Upon examination it was found that these two rooms that were adjacent were only divided by folding doors, and the doors were kept open. There was a fireplace and chimney in each, but while one was effective (there was a fire burning in it at the time) the other was quite the reverse, and it caused the odour complained of. The air seemed to issue from this chimney into the room instead of being the other way about. Further examination showed that, with the view of making the rooms very cosy and free from draughts, the crevices all round the doors, and also the windows, had been neatly and well fitted with draught tubing, and the rooms were practically air-tight when the doors and windows were closed. These were kept closed as a matter of course in the severe weather when fires were needed. Now where was the air needed for the chimney draught to come from? The first thought would be that both chimneys would fail to act, there would and could not be any up-draught in them. This, however, can rarely be the case, as the power of the chimneys would not be so exactly balanced. Furthermore, whichever had the fire lighted first would be rendered more effective than the other, and once there is that which goes to make the chimney act in the way it should, the air will rush in from somewhere, and in this instance it came down the other chimney, for there was no other way. The occupants had tried to stop it by closing the folding doors; but these did not fit at all closely; if they had, then there would have been every chance of both chimneys being failures. Of course, the down-draught in this particular chimney was instantly stopped when a door or window was opened to let a supply of air in, but to have a door or window constantly open could not be thought of, so the trouble was overcome with an inlet ventilator placed in each room. The cause of the trouble was merely want of air. It had happened in this very instance that a local tradesman had been called in, and he volunteered the information that his cures of down-draught were very numerous, as he had a patent pot of his own that was irresistible. Of course, he put one of these pots on, and equally of course it did no good whatever. He then attributed the trouble to a supposed defective state of the chimney, and from first to last he never went into the room where the trouble was noticeable—he had no need, he said. It is a too common practice for people to think that application must be had to the top of every troublesome chimney; certainly with quite the majority of instances of down-draught the top is the part to be attacked; but otherwise it is as often the bottom where the cure will be effected.

In case it should have been gathered from what was just said, that short or low chimneys are not effective, it must be clearly explained that their non-effectiveness when it occurs is entirely due to their surroundings. A short chimney will work well if there is nothing higher adjacent to it, and, in fact, when working stoves and cooking ranges in open fields, military camps, etc., it is astonishing how effective a very short chimney will be found. As this is being written there is a gas-fire near by, and this has a pipe-chimney to it, which is only 4 ft. in its extreme height. Although this is so short, the passage of hot gases up it make quite a loud and hoarse humming noise; in fact, it is too effective, for it lessens the effectiveness of the stove a little. A cooking range at Aldershot in a low building has 8 ft. of pipe to act as a chimney, and remarkable though it may seem, this induces sufficient draught to draw the flame and smoke from the fire round the oven, to all appearances as well as a tall brick chimney would do. At any rate, the range works most successfully, and shows no need for improvement. (F. DYE in 'The Building News.')

CHINA RIVETING.

BROKEN CHINAWARE RIVETING.

(*See also* CEMENTS FOR CHINA, CUTTING GLAZED TILES, ETC.)

(*a*) The riveting of china and earthenware, if carefully done, is the most substantial way of effecting repairs. The appearance is not usually as good as cementing, but in riveting china, one of the first rules is to put the rivets in the least conspicuous spots consistent with doing the job strongly. The "rivets," as they are called, are pieces of brass wire bent down at the ends, as in Fig. 89. The wire is about $\frac{1}{16}$ in. thick and is flattened. The flattening may be done on one side only (the side that comes next to the china), in which case it is done with a file; or the two bent-down ends may be left of round wire, while the connecting piece is flattened a little by hammering. The idea is to get the wire to lie close against the china. If the rivet is to come on a curved surface, it is bent to correspond.

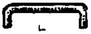

FIG. 89.

The holes are made in the china a little larger than the wire of the rivet, at about $\frac{1}{4}$ in. from the edge of the break, and slanting slightly downwards towards it, as Fig. 90, to correspond with the slight slant given to the ends of the rivet. The measurement of the holes and the rivets should be exact, and the latter should be made so that the ends will only just go in the holes, or will barely do so. In the latter case heat is relied on to expand and lengthen the rivet slightly, so that it will go in and then pull itself up tightly as it cools. Without heat the rivet is made so that

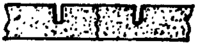

FIG. 90.

it has to be gently driven in with a small hammer or wooden mallet. The final fixing of the rivet is done, if hot with shellac, or if cold with plaster of Paris. The latter can be coloured if desired, and a little fluid plaster is well worked into the crack (after the riveting), to make it water-tight if it appears necessary. The holes drilled in the china should be of a depth of about half the thickness of the china, or a trifle more if the china is thin, and the turned down ends of the rivets must on no account be longer than the depth of the holes.

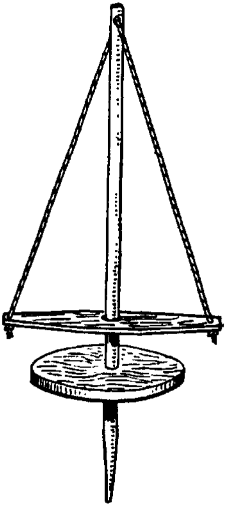
FIG. 91.

The drilling can be done by an archimedean drilling tool, or a hand brace, or a fiddle or bow drill, but the tool most commonly used, particularly by the peddling fraternity is an ingenious drill stock that can be made of three pieces of wood and a length of string, Fig. 91. The centre shaft is a rod about ½ in. thick, and say, 18 in. long. The cross-piece to which the string is attached, is about 7 in. in length, the middle hole in it being a little larger than the rod. The circular piece acts as a fly-wheel, and may be 4½ in. in diameter, by ⅝ in. thick, and fits the rod tightly. By holding the cross-piece, then giving the rod a twist to start it, the string will wind itself on, as in Fig. 92; then, by pressing down the cross-piece the rod will be made to revolve, and if the pressure is relieved just as the string has become unwound, the impetus given the fly-wheel will carry the rotation on sufficiently to wind the string on again the other way. The cross-piece is then pressed down again and the operation repeated. The rotation of the rod is thus several turns one way, followed by a corresponding number of turns the other way, and so on as long as the cross-piece is worked by the hand.

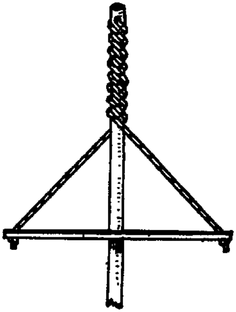
FIG. 92.

FIG. 93.

The drilling point may be of steel, or of copper, as mentioned in the following matter, turpentine being used as a lubricant, but to start the hole through the glazed surface—which is the hardest part—a diamond-pointed drill as Fig. 93 is sometimes used.

This is a piece of diamond (the kind used in many larger drilling tools) firmly secured in the end of a tin tube, either by cementing or soldering. This tube slips on to the lower end of the rod of the drilling stock just described.

(*b*) Ceramic objects can be readily drilled with hardened steel tools. With majolica and porcelain without glaze it is best to drill under water; for instance, filling the vessel with water and placing it in another vessel filled with water, so that the drill is used under water and passes again into it after penetrating the material. Instead of filling glazed articles with water, a piece of cork may be placed under the spot where the drill is working. The pressure applied to the drill varies according to the hardness of the material; it must, however, gradually decrease as the drill approaches the point of exit, and finally cease altogether in order to avoid splintering. For enlarging small holes already existing it is best to use three-cornered or four-square broaches, ground smooth, in the same manner as above described (under water); for hard material, such as glass and glaze, moisten the broach with oil of turpentine. The simultaneous use of oil of turpentine and water is best in all cases, and especially when the object to be drilled does not permit the sole use of the oil as in the case of majolica and unglazed porcelain, as the oil will be absorbed if water is not used.

(*c*) Boring the holes is generally done with a diamond-pointed drill or copper bit with corundum or emery. To make cutting tool, take piece of stout copper wire or rod, and fit to drill. See that it is perfectly straight. Next make the copper red hot, and plunge into cold water. Now take bit of hard wood, say box or oak, about ¼ in. to ⅜ in. thick and 1 in. or so square. Drill hole in it just large enough to take copper bit, put a few grains of emery powder in the hole, and insert copper bit. Press down firmly, and give a few turns. Add more emery, repeat process until end of copper is embedded with grains of emery. The bit requires renewing with emery at intervals, and can be kept moist with turpentine, or paraffin, or camphor dissolved in turpentine.

To Drill Glass.—In drilling glass stick a piece of stiff clay or putty on the part where you wish to make the hole. Make a hole in the putty, exposing the glass to the size required. Into this hole pour a little molten lead, when, unless it is very thick glass, the piece will immediately drop out.

To File Glass Utensils.—Dip the file in strong caustic soda lye, and then, while still wet into coarse sand. With a file thus prepared glass utensils can be worked without cracking the glass.

* * *

CHISEL STEEL.

ITS TREATMENT.

THE following is extracted from a paper read before the National Railroad Blacksmiths' Association of America.

The operation of making and dressing chisels appears so easy and simple that it is scarcely given any attention, and many are of the opinion that a cheap grade of steel is perfectly suitable for the purpose. There are various reasons why good steel should be used for this purpose, viz. they must hold a good cutting edge, they undergo many redressings, they are subjected to impact, and they are often used by inexperienced workmen. Cheap steel, when reheated and retempered many times, deteriorates very rapidly when compared with good steel. This cheap steel has a very open and loose structure; also, it contains a greater percentage of the impurities; these impurities envelop the grains and prevent the necessary cohesion from taking place between the grains. These vibrations which take place when a chisel is struck a blow from the hammer are very conducive to fatigue in poor steel, and in this condition a chisel will break in a very short time. They do not exert such a marked influence on good steel, and, furthermore, this rule will also apply to iron in the same respect.

In making chisels care should be taken to clip off the corners; if not, they will draw over and overlap the interior metal, which will produce a split point. I believe in edging-up, or, in other words, upsetting edgewise, when the point of the chisel is very thin, and it being at a dull-red heat is the cause of more chisels breaking than any other treatment it receives, unless it be overheating for hardening. The smith should aim to do most of his edging-up before the chisel is drawn down too thin; if it should spread a little wider than the width of the steel, it would be better to leave it in this shape than to edge it up when it is very thin.

In order to obtain the best results a good hammering to pack the steel is very essential, but it should be properly done. The chisel should be evenly heated, and the process of packing should commence at the thicker part of the chisel first, gradually increasing the amount of hammering on reaching the point, and aiming to give an equal amount of it on each side. At times we have a difficulty with chisel points snapping off; there are good reasons for these failures. First, when a chisel is unevenly heated, and quenched in this condition, it is left in a state of unequal tension; then we find areas with different degrees of hardness; also the transition from the hard areas to the soft being so abrupt, the chisel is left in a state of great weakness.

Secondly, the point of the chisel is heated to the proper temperature, but just back of this (say about $\frac{5}{8}$ in.) the colour is scarcely visible; it is quenched in this condition. This chisel will break at the junction between the hardened and the unhardened parts. The smith will then test the fracture with his file; finding it very soft, he wonders why it broke.

When steel is quenched between what is called the neutral and hardening zone, or, in other words, just before it arrives at the true hardening heat, it is in its weakest condition, and this accounts for the point jumping off. This can be remedied by hardening the chisel farther up where it is thicker and stronger, and then drawing the temper accordingly.

A practice which should not be tolerated is when the chisel point is heating too fast and it is checked by dipping it into the water (just for an instant) and then placed in the fire again.

In dressing chisels many are returned having considerable temper remaining; generally they are thrust into the centre of the fire; here the change is so sudden that the tenacity of the steel is impaired, and at times will cause surface cracks.

The use of sulphurous coal is also quite a factor in causing unsatisfactory results.

It seems also unnecessary to mention that quick heating and overheating in any part of the treatment is the cause of many failures.

We will make a number of the chisels from the same bar of steel, and will declare they all received precisely the same treatment; but will the final results support us in this claim? I believe not, for there must have been a variation in the treatment somewhere for the machinist (who is a careful man) will state that some broke very easily, while others were exceptionally good; until we can explain why this is so, we should refrain from upbraiding our friend when he returns with these chisels broken. Many efforts have been made for the purpose of taking a short cut on this undesirable task of chisel dressing, but the old method still prevails to a great extent.

Some have recommended the use of lead, others cyanide of potash, which is heated in a ladle or pot to the proper temperature, and the chisel points are placed in this till they attain the desired heat, but if these mediums are not kept at the proper temperature the results will be very unsatisfactory. Some advise heating the points in the fire and then quenching in oil or a mixture of tallow, prussiate of potash. and resin; then, again, tin that is just brought to the melting-point is used. It is claimed that when quenched in any of these mediums the temper need not be drawn; it will be ready for use. For my part, I do not believe that they are worth while considering.

Some practise drawing the temper very slowly in oil or sand which is heated to the proper temperature to give the required hardness to the chisel.

It would be well to give a little attention to the water emery-wheels in use at so many places at the present time; they are usually too fine for the purpose intended, which causes them to glaze very quickly when used on hardened steel. They are the cause of many surface cracks which we see on the cutting edge of the tools, especially those made from alloyed steel. The tools are thrust against this glazed surface of the emery-wheel with considerable pressure; the wheel will not cut, but glide over the surface of the tool; this friction generates heat so quickly that it exceeds the conduction power of the steel. Consequently only a thin shell of the steel is heated; expansion must take place but the internal condition of the steel being cold and unyielding, this thin shell relieves itself by cracking. Then again, tools ground on wheels in this condition will become soft as well as glazed, and thus will require hardening again; but this glazed film prevents hardening from taking place, and then we will blame the steel for being deficient in carbon. These emery-wheels will often take the temper out of the extreme cutting edge, which will not penetrate more than ·001 of an inch beyond the surface; but it is enough, for the tool gives down very quickly, and on such tools as mills it is liable to break out the teeth.

In some places when tools are to be annealed they are placed in a furnace that is heated to a very high temperature. This is a bad practice, and should not be continued on such tools as mill, hobs, reamers, etc., for the small teeth are heated so quickly that it will cause a strain at the base of the teeth. Then if the old teeth are not entirely cut away (which is often the case), it will be disposed to crash at these strains when tempered. It is well known that steel on being hardened will change from its original size when cold. Generally an expansion will take place; but it is not unusual to have a piece that will show a slight shrinkage.

At times we will notice pieces of steel which conform exactly to the same size and shape, made in the same manner, and from the same bar of steel, when hardened, they will show a slight difference in the expansion, and perhaps a piece or two will show a slight contraction. We feel confident that we heated these pieces the same temperature; but the eye is very easily deceived and every little increment or decrement in temperature of water will have an influence in producing different results.

These variations, being very small, would not count on many pieces to be hardened for ordinary work, but on such tools as master-taps and dies it would probably render them worthless.

Some blame the steel for these variations, but I believe it is due partly to our method of hardening. The following I have copied from a little book, which will partly explain the difficulty: "In pieces of steel above a certain size the hardness does not extend right through to the centre. The surface, when it is suddenly cooled, contracts to a certain extent and exerts a considerable compressive force on the metal in the interior, which, as it slowly cools, is forced to occupy a smaller volume than it did originally; whilst the hardened portion, which is in a state of tension, owing to it having been cooled suddenly, occupies a greater. If, then, the contraction of the interior be greater than the expansion of the exterior, the piece of steel, as a whole, will be smaller after hardening than it was before, and *vice versâ*. The whole question turns on the relation of the volume of the hardened portion to that which has been only partially hardened."

* * *

CLEANSING.

(*See also* BLEACHING, LACQUERING, POLISHING, GILDING, PLATING, ETC.)

THIS subject embraces washing and scouring processes, recipes for cleansing various articles of a hard or solid nature, also recipes for the removal of stains.

Alabaster (*and see* MARBLE).—Strong soap and water is good for cleaning alabaster; if too much discoloured make a paste with quicklime and water, cover the article well with it, and let it remain all day; wash off with soap and water, rubbing hard the stains. Or apply dilute muriatic acid, having previously washed off dirt and grease.

Bottles (*and see* DRUGGISTS' UTENSILS, *and* GLASS).—(1) Do not use lead shot as it is a dirty and objectionable method, clippings of iron wire are a better means of rinsing. They are easily had, and the cleaning is rapid and complete. The iron is attacked by the oxygen of the air, but the ferruginous compound does not attach to the side of the bottle, and is easily removed in washing. Fordos found that the small traces of iron left had no apparent effect on the colour of red wines; it had on white wines, but very little; but he thinks it might be better to use clippings of tin for the latter. (2) Take a handful of common quicklime, such as bricklayers use, and a handful of common washing soda; boil them in a large kitchen iron saucepan (which will only be cleaned, not damaged, by the process). When cold, the fluid will be lye; put this into the vessel you want to clean with some small pebbles; make it warm if you can, and shake up or let it soak according to the nature of the vessel. (3) Gypsum (free from silicate), marble, or bruised bones, is preferable to shot or sand. Sulphuric acid and bichromate mixed, are best to free porcelain and glass from organic matter.

(4) *Bottles containing Resinous Solutions.*—Wash with caustic alkaline lyes, and rinse with alcohol; if they have held essential oils, wash with sulphuric acid, and rinse with water.

(5) *Glass Bottles which have contained Petroleum.*—Wash with thin milk of lime, which forms an emulsion with the petroleum, and removes every trace of it; by washing a second time with milk of lime and a small quantity of chloride of lime, even the smell may be so completely removed as to render the vessel, thus cleansed, fit for keeping beer in. If the milk of lime be used warm, instead of cold, the operation is rendered much shorter. ('Ding. Pol. Jl.')

Brass (*and see* LACQUERING). — The cleaning of lacquered goods must be confined to simple washing, strong soda water being used to remove lacquer when relacquering is to be done (*see* LACQUERING). The following recipes are for cleaning brass articles with polished uncoated surfaces.

(*a*) Wash with rock alum, boiled in a strong lye in the proportion of 1 oz. to a pint; polish with dry tripoli. (*b*) Make a mixture of 1 part common nitric acid and ½ part sulphuric acid, in a stone jar, having also ready a pail of fresh water and a box of sawdust. The articles to be treated are dipped into the acid, then removed into the water, and finally rubbed with sawdust. This immediately changes them to a brilliant colour. If the brass has become greasy, it is first dipped in a strong solution of potash and soda in warm water; this cuts the grease, so that the acid has free power to act. (*c*) Rub the surface of the metal with rottenstone and sweet oil, then rub off with a piece of cotton flannel, and polish with soft leather. (*d*) A solution of oxalic acid rubbed over tarnished brass soon removes the tarnish, rendering the metal bright. The acid must be washed off with water, and the brass rubbed with whiting and soft leather. (*e*) A mixture of muriatic acid and alum dissolved in water imparts a golden colour to brass articles that are steeped in it for a few seconds. (*f*) Put a coat of nitric acid over the part you want cleaned, with a piece of rag; as soon as it turns a light yellow, rub it dry, and the brass will present a very clean appearance; if not, repeat. (*g*) Oxalic acid and whiting mixed and applied wet, with brush, and brushed again when dry with soft plate-brush, polishing with dry whiting.

Brass Instruments.—(*a*) If the instruments are very much oxidised or covered with green rust, first wash them with strong soda and water. If not so very bad, this first process may be dispensed with. Then apply a mixture of 1 part common sulphuric acid and 12 of water, mixed in an earthen vessel, afterwards well scouring with oil and rottenstone, and finally using a piece of soft leather and a little dry rottenstone to give a brilliant polish. In future cleaning, oil and rottenstone will be found sufficient. To hold the instrument, get a piece of wood turned to insert in the bells; fix in a bench vice. The piece of wood will also serve for taking out any dents you may get in the bells. (*b*) Dissolve some common soda in warm water, shred into it some scraps of yellow soap, and boil it till the soap is all melted. Then take it from the fire, and when it is cool add a little turpentine, and sufficient rottenstone to make a stiff paste. Keep it in a tin box covered from the air, and if it get hard, moisten with a small quantity of water for use.

Brass or Copper.—Mix together 1 oz. oxalic acid, 6 oz. rottenstone, and ½ oz. gum arabic; all these are to be finely powdered. Then add 1 oz. sweet oil and sufficient water to form the mixture into a paste. Apply a small portion to the article to be cleaned, and rub dry with a flannel or washleather.

Brass Inlaid Work.—Mix tripoli and linseed-oil, and dip felt into the preparation. With this polish. If the wood be rosewood or ebony, polish it with finely-powdered elder ashes, or make a polishing paste of rottenstone, a pinch of starch, sweet oil, and oxalic acid, mixed with water.

Bronze.—(1) There has been found no other way of cleaning bronze statues, when blackened by smoke and soot, than that of washing with plenty of clean water, accompanied with mechanical friction; but even this simple treatment is very undesirable; because the friction, however slight, accompanying the washing, destroys, or tends to destroy, the sharpness of the outlines; and the sulphurous and sulphuric acids of the prevailing smoke would be certain to rapidly corrode the surface of any bronze statue which is constantly being washed. It has been a matter of much debate whether the soot-blackened surface of a bronze statue is not more pleasing to the eye than the metallic lustre of a new, or newly-cleaned statue. (2) Weber finds that a dilute solution of caustic alkalies removes overlying dirt, and allows the green patina to become visible. Where the metal was not originally oxidised, the alkali simply cleanses it, and does not promote any formation of green rust. (3) By dipping fustian in soluble glass, and washing it with soap directly afterwards, we get a fabric largely impregnated with silica, which will be found very well adapted for cleaning bronzes, etc. (4) The method of restoring a bronze tea-urn turned black in parts will depend, to a great extent, on the metal and the colour. Clean the surface, first of all, with whiting and water, or crocus powder, until it is polished; then cover with a paste of graphite and crocus, mixed in the proportions that will produce the desired colour. Heat the paste over a small charcoal fire. If the bronzing has been produced by a corrosive process, try painting a solution of sulphuret of potassium over the cleaned metal. The bronzed surface may be polished; but it cannot be bright unless the surface of the metal itself is polished, and then covered with transparent lacquer to preserve the brightness. (5) Boil the articles in ordinary soap-boilers' lye, rinse in water, and roll in bran or sawdust. If the bronze is pressed, the lye must be mixed with common salt and the article thoroughly brushed, but no water must touch the back. (6) Bronze which has become dirty by oil, fat, tallow, or other greasy body, is boiled in an infusion of ashes, and cleansed with a soft brush dipped in a fluid of equal parts of water, nitric acid, and alum. Each piece is then dried with a rag, and slightly heated. To cleanse clock pendulums, and free them from the substance called by the gilders "mercury-dust," heat them moderately, touch the stain with a brush dipped in nitric acid, rub with a linen rag, and again heat moderately.

Carpets. *Vacuum Cleaning.*—The vacuum system, which may be said to suck the loose dirt from the carpets (for it cannot remove fixed dirt marks or stains, though by removing loose dirt from fixed marks it may make them less pronounced), is now being largely used owing to the many advantages it offers. In the first place it raises no dust, does not scatter a proportion of the dirt disturbed, as any brushing process must; it is more positive, removing more dirt from beneath a carpet than a brush can get at. It may not be as effective as taking up carpets and underfelts, beating them and washing the floor, but for ordinary periodical thorough cleaning as required in hotels and similar places, the vacuum method is considered to make the raising of fixed carpets unnecessary. With a public dining (general meal) room, the raising of the carpet and its cleaning would mean stopping business for a day or two at least; while the cleaning of sitting and bedroom carpets, by raising them, would keep a certain percentage of rooms perpetually unfit for occupation. Vacuum cleaning is quite as quick as surface brushing, and in certain pressing cases it is undertaken without even removing the hangings in the room.

The vacuum is produced by an air pump, this being driven by a petrol or similar motor (when the outfit is portable and carried in a van from house to house). A good vacuum of 25 in. is easily got, and the general working of the system presents no difficulties. The chief detail, that is kept secret as far as possible, is the "dirt-arrester." A pump that may be effective and free working with air will quickly fail if the air is loaded with dust and debris, and the duty of the dirt-arrester is to filter this out of the air which is drawn through the substance of the carpet and which of course disengages and carries the dirt from the carpet with it. The details of an arrester are given in Fig. 94, this showing the interior construction in section. Its exterior is simply a box or case, or any convenient shape, the interior being divided up and including a coke air-filter bed as shown. The case must have a door to admit of the dirt being removed (and the coke which will require washing or renewing) and, needless to add, the door, and the whole case, must be absolutely air-tight. The cleaning out of the box must be done as often as the operator judges best, this being governed by the size of the box and the state of the carpet.

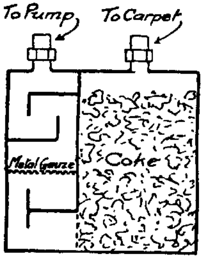

FIG. 94.

Casks (*Beer Casks*).—The acid smell very often found in casks may be attributed to absorption in the pores of the wood of acetic and lactic acids—a very small quantity of either of them having power to communicate their principle to any fermenting liquid with which they may be brought in contact, and increasing very fast at the expense of the alcohol in the liquid, while at the same time causing unsoundness to a greater or less extent, according as the temperature of the atmosphere may be high or low. Bearing this in mind, it is of the utmost importance that all free acid which the cask may contain should be carefully neutralised before filling with a liquid so liable to change as fermenting wort. Casks before filling, after being well washed with boiling water, should be allowed to cool, and then examined by some responsible person as to their cleanliness, acidity, and probable mustiness; the cask is well smelt, and usually a light is passed through the tap-hole, so that the examiner may view the interior. Any cask that may smell sour (especially in summer weather, or when required for stock or pale ales) should be rejected, and be well treated with lime. This should be put into the casks *dry*, small lumps of the lime being broken, so that they can be easily inserted in the bung-holes, and when sufficient has been put in (say, about 4 lb. to a barrel), then about 4 gal. of *boiling* water must be added, the casks bunged up, and kept so for a few hours, occasionally rolling about. The lime should then be well washed out, and the casks steamed, and allowed to cool, when they will be in a fit condition for containing the most delicate liquid without any injury. The hard brown substance, which on being scraped with a nail leaves a white mark, so often found in casks, is a deposit that forms from the constituents of the liquid contained in them, and is often carbonate of lime, or yeast dried, or both. When this is formed, the only effectual method of cleansing is to take out the head, and put it into the cooper's hands to be well scraped; until every particle of the fur is removed. Cask-washing machines never remove fur or thick dry deposit properly; they are very convenient in a general way for the usual run of casks, but any exceptionally bad must be unheaded, and cleaned by hand. For stock ales it is a good plan to rinse with solution of bisulphite of lime just before filling trade casks. (2) With regard to the coating spoken of in (1), it not only preserves the wood but keeps it clean and sweet, and does no harm at all to the beer. It takes some considerable time before the wood is coated with such a protecting enamel. It occurs alike in rounds, puncheons, and stone squares. Formerly it was customary to have all vessels that were furred over thoroughly dressed by the cooper, but now intelligent coopers advise brewers to keep it on. (3) Blow sulphur fumes into foul casks by fumigating bellows, such as gardeners use when fumigating conservatories. The sulphurous acid formed by burning brimstone is a powerful purifier, and will not leave an unpleasant taste, being easily washed away.

Cider Casks.—(*a*) Half fill each cask with boiling water, and add ¼ lb. of pearlash, then bung it up, and turn over occasionally for 2 days, then empty, and wash with boiling water. (*b*) Scald out with boiling water; if the heads are out, put them over a straw fire for a few minutes, so as to slightly char the inside. If you have a steam boiler, partially fill with water, and admit steam through the bunghole by a pipe down into the water, and so boil.

Vinegar Casks.—Old vinegar barrels become impregnated to such an extent with acetous substances that it is next to impossible to render them fit for the storage of any other liquid. Fill the barrels with milk of lime, and let this remain in them for several months, then rinse out well with plenty of warm water, and steam them inside for ½ hour.

Celluloid Covered Mountings.—Rub the covered parts with a woollen cloth and a little tripoli, and polish with a clean woollen rag.

Chip or Straw Bonnets.—*To Clean.*—Wash in warm soap liquor, well brushing them both inside and out; then rinse in cold water, and they are ready for bleaching.

To Bleach.—(1) Put a small quantity of salts of sorrel or oxalic acid into a clean pan, and pour on it sufficient scalding water to cover the bonnet or hat. Put the bonnet or hat into this liquor, and let it remain in it for about 5 minutes; to keep it covered, hold it down with a clean stick. Dry in the sun or before a clear fire. (2) Having first dried the bonnet or hat, put it, together with a saucer of burning sulphur, into a box with a tight closing lid. Cover it over to keep it in the fumes, and let it remain for a few hours. The disadvantage of bleaching with sulphur is that the articles so bleached soon become yellow, which does not happen to them when they are bleached by oxalic acid.

To Finish or Stiffen.—After cleaning and bleaching, white bonnets should be stiffened with parchment size. Black or coloured bonnets are finished with a size made from the best glue.

Straw or chip plaits, or leghorn hats and bonnets, may also be cleaned, bleached and finished as above.

Cloth and Clothing.—(*See also* TEXTILE FABRICS *and* STAINS.)

Clothes, Washing compound for.—The German washerwomen use a mixture of 2 oz. turpentine and 1 oz. spirits of ammonia well mixed together. This is put into a bucket of warm water, in which ¼ lb. soap has been dissolved. The clothes are immersed for 24 hours and then washed. The cleansing is said to be greatly quickened, and 2 or 3 rinsings in cold water remove the turpentine smell.

Solution for cleaning Clothes.—For tweeds and silks the following is good. Methylated spirit ½ oz., strong spirit of ammonia 1 oz., spirit of naphtha 30 drops. Take one tablespoonful of this mixture and stir it into half a pint of warm water. Apply with a brush but do not soak the material.

Coins.—Coins can be quickly cleansed by immersion in strong nitric acid, and immediate washing in water. If very dirty, or corroded with verdigris, it is better to give them a rubbing with the following:—

½ oz. pure bichromate of potash.
1 oz. sulphuric acid.
1 oz. nitric acid.

Rub over, wash with water, wipe dry, and polish with rottenstone or chalk. (Lyle.)

Copper Vessels.—(1) Use soft-soap and rottenstone, made into a stiff paste with water, and dissolved by gently simmering in a water-bath. Rub on with a woollen rag, and polish with dry whiting and rottenstone. Finish with a leather and dry whiting. *See also* Brass.

Cotton Waste.—Clean in a solution of washing soda (carbonate of soda and hot water); the resulting liquor will be soapy which may be used as a lubricant in the workshop for drills, etc.

Druggists' Utensils.—Before cleaning an implement, the first thing to consider is whether the article you are about to wash is worth the chemical you will have to waste upon it. If not, then throw it away; if otherwise, the chemicals are not wasted. Do not count the labour, as it would be the same even if merely washing with water. On any article use water first—pure water, or as pure as it runs from the hydrants, and next to that soap. I place water first, as it ought to be, in an apothecary's shop. Other people place soap first; but soap is incompatible with a great many chemicals employed in a drug store, and in some cases had better be left out altogether. Water will dissolve out most iodides, nitrates, sulphates, chlorides, etc., with which soap is incompatible, even if they are incorporated with fatty substances as in ointments. We have known clerks to dash soapsuds right into a graduate that has contained tincture of iron, or solutions of lead, or lime, and then have a graduate more difficult to wash out than before, while, if they had used water alone, it would have been cleansed.

Cheapness is the thing to be desired in washing paraphernalia. Some druggists use powdered pumice, sawdust, sand brick, shot, wire and paper, solutions of soap in diluted alcohol, and of caustic potash in water, turpentine, ammonia, benzine, alcohol, ether, chloroform, hot water, and hydrochloric, nitric and sulphuric acids. Some of the above are to be recommended, and others are not; for instance, powdered pumice is an excellent thing for scouring wedgwood mortars and brightening spatulas. It is also useful when introduced into bottles on paper and a bent wire employed for scouring.

Dry sawdust is good for removing grease from mortars and spatulas after ointments have been made, and in soaking up oil and paint from floors when spilled. Sand brick is useful in scouring spatulas. A very handy instrument is the bent wire and paper. With a good steel wire bent into proper shape and introduced into bottles, we can accomplish wonders. A piece of newspaper, moistened and sprinkled with powdered pumice, will scour out of a bottle all dirt of a resinous character. If the bottle has contained any solutions of iron salts, use hydrochloric acid. A bottle that has contained lime-water, or in which lime has deposited, is most readily cleansed by hydrochloric acid. The same is true of oxide of zinc when used in a mortar for making ointments. A mortar after zinc ointment has been prepared in it, if washed ever so much with soap and water, still causes a little water dropped into it to run into globules, showing the presence of zinc or other substance in the mortar. A few drops of muriatic acid dropped into it will remedy this, forming chloride of zinc, a very soluble salt.

Nitric acid will best cleanse a vessel that has contained lead solutions, as the other acids form insoluble lead compounds. Carbonate of soda put into fish-oil or cod-liver-oil bottles, and allowed to stand a few hours, will cleanse them perfectly. A solution of crude potash is an excellent thing to keep on hand, as it is to be preferred to alcohol, ether, benzine, or chloroform, in cleaning vessels that have contained resins, such as liquid storax, tolu, benzoin, and all dirt of a resinous character; it is also useful in cleaning vessels which have contained Prussian blue. Alcohol is useful in removing chlorophyll. For ether and chloroform I have no use, as they are too volatile and too expensive.

Hot water for grease is not to be recommended, because it is not handy to get, and it only melts the grease, and causes it to float on its surface, and when the water is poured out of the vessel the fat will still adhere to its sides, and have to be washed off with soap and water. Turpentine is useful in removing tar, wax, or resin. I never have had enough success with ammonia to recommend it. It destroys paint if put on counters or shelving, and makes windows look smeary. The only thing it is good for is to neutralise acids that may have fallen on clothing. Oxalic acid will temporarily remove tannate of iron stains. Use whiting, or better, precipitated chalk on your plated show-cases, and rottenstone on brass work. A chamois skin is good to brighten up things with, but a new one scratches, and an old one, if washed, is hard and stiff.

And now we come to the last, but not least important, and that is the hands; all the above solvents and detergents will do for the hands, if used in moderation, and then immediately removed with clear water. (A. Wetterström.)

Earthenware, Porous.—This often becomes foul with organic matter when used to hold water. Use 1 oz. muriatic acid, rubbed on exterior and interior with a piece of flannel. Wash afterward with hot water.

Engravings. — (1) Presuming these to be mounted, proceed in the following manner. Cut a stale loaf in half, with a perfectly clean knife; pare the crust away from the edges. Place the engravings on a flat table, and rubbing the surface with the fresh-cut bread, in circular sweeps, lightly but firmly performed, will remove all superficial markings. Soak the prints for a short time in a dilute solution of hydrochloric acid, say 1 part acid to a 100 of water, and then remove them into a vessel containing a sufficient quantity of clear chloride of lime-water to cover them. Leave them here until bleached to the desired point. Remove, rinse well by allowing to stand an hour in a pan in which a constant stream of water is allowed to flow, and finally dry off by spreading on clean cloths. Perhaps the engraving may afterwards require ironing between two sheets of clean paper. (2) Put the engraving on a smooth board, cover it thinly with common salt finely pounded; squeeze lemon-juice upon the salt so as to dissolve a considerable proportion of it; elevate one end of the board, so that it may form an angle of about 45° or 50° with the horizon. Pour on the engraving boiling water from a tea-kettle until the salt and lemon-juice be all washed off; the engraving will then be perfectly clean, and free from stains. It must be dried on the board, or some smooth surface, gradually. If dried by the fire or the sun it will be tinged with a yellow colour. (3) Hydrochloric acid, oxalic acid, or eau de Javelle may be employed, weakened by water. After the leaves (if it be a book) have by this means been whitened, they must be bathed again in a solution of sulphate of soda, which will remove all the chlorine, and leave the leaves white and clean. They will, however, have lost all firmness of texture, owing to the removal of the size from the paper. It will, therefore, be advisable to give a bath of gelatine and alum, made with boiling water, to which may be added a little tobacco, or any other simple substance to restore the tint of the now too white paper. (4) Immerse each mildewed sheet separately in a solution made in the proportions of ½ lb. chloride of lime to a pint of water. Let it stand, with frequent stirring, for 24 hours, and then strain through muslin, and finally add 1 qt. water. Mildew and other stains will be found to disappear very quickly, and the sheets must then be passed separately through clear water, or the chloride of lime, if left in the paper, will cause it to rot. Old prints, engravings, and every description of printed matter may be successfully treated in the same manner. (5) "I have in my time cleaned many hundreds. The plan which I adopt is as follows: I place them, one or two at a time, in a shallow dish, and pour water over them until they are completely soaked or saturated with it. I then carefully pour off the water, and pour on to the prints a solution of chloride of lime (1 part liquor calcis chloratæ, to 39 parts of water). As a general rule, the stains disappear as if by magic, but occasionally they are obstinate. When that is the case, I pour on the spot pure liquor calcis chloratæ, and if that does not succeed, I add a little dilute nitro-muriatic acid. I have never had a print which has not succumbed to this treatment—in fact, as a rule they become too white. As soon as they are clean they must be carefully washed with successive portions of water until the whole of the chlorine is got rid of. They should then be placed in a very weak solution of isinglass or glue, and many collectors colour this solution with coffee-grounds, etc., to give a yellow tint to the print. They should be dried between folds of blotting-paper, either in a press or under a heavy book, and finally ironed with an ordinary flat-iron to restore the gloss; placing clean paper between the iron and the print. Grease stains are much more difficult. I find benzine best. Small grease spots may be removed by powdered French chalk being placed over them, a piece of clean blotting-paper over the chalk, and a hot iron over that." (F. Andrews.) (6) Mildew often arises from the paste used to attach the print. Take a solution of alum of medium strength and brush on back and face of the engraving 2 or 3 coats, then make the frame air-tight by pasting a strip of paper all round the inside of glass, leaving about ½ in. overlapping (taking care not to paste the paper on the glass, so as to be seen from the front), then place your glass in frame, take the overlapping piece and paste to side of rebate; place your picture in position, spring backboard in, and then place a sheet of strong paper (brown) on the table, damp it, and paste round back of frame, lay it on to the paper, leave to dry, cut level. If this does not answer, there will be no help for it, but dust off as the mould accumulates. Do not brush on surface with the alum if the engraving is coloured, but several coats on the back. (7) A plan recommended by Wm. Brooks is to get a dish or china tray a little larger than the engraving to be operated upon; if smaller, there is a great risk of tearing and damaging the engraving. The bleaching agent used is Holmes' ozone bleach. The strength preferred is 1 part bleach to 10 of water, well shaken up before pouring into the dish. A much stronger solution can be used (say 1 in 5), but the weaker it is, the easier is its removal from the paper afterwards. The engraving is immersed in the solution face upwards, avoiding bubbles. The only caution to be observed is that the sodden engraving is somewhat rotten, and needs careful handling. If the engraving be only slightly stained, ½ hour will suffice to clean it, but if quite brown it may require 4 hours. After all the stains are removed, and the paper has regained its whiteness, pour the solution back into the bottle, as it can be reused till it becomes discoloured; fill up the dish with water, changing frequently for about 8 hours, or place it in running water. When the engraving is sufficiently washed, it can be taken out, blotted off, and hung up to dry. When quite dry, it may be ironed on the back with a warm flat into fish-oil or cod-liver-oil bottles, and allowed to stand a few hours, will cleanse them perfectly. A solution of crude potash is an excellent thing to keep on hand, as it is to be preferred to alcohol, ether, benzine, or chloroform, in cleaning vessels that have contained resins, such as liquid storax, tolu, benzoin, and all dirt of a resinous character; it is also useful in cleaning vessels which have contained Prussian blue. Alcohol is useful in removing chlorophyll. For ether and chloroform I have no use, as they are too volatile and too expensive.

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Grebe.—Carefully take out the lining, and wash with warm water and soap, as directed for white ostrich feathers, but do not shake them until they are quite dry. Before re-making, carefully repair any rents there may be in the skin.

To purify Feathers for Beds, Pillows, etc.—Prepare a quantity of lime-water in the following manner: Well mix 1 lb. of quicklime in each gal. of water required, and let it stand until all the undissolved lime is precipitated, as a fine powder, to the bottom of the tub or pan, then pour off the clear liquor for use. The number of gallons to be prepared will, of course, depend on the quantity of feathers to be cleaned. Put the feathers into a clean tub, pour the lime-water on them, and well stir them in it, until they all sink to the bottom. There should then be sufficient of the lime-water to cover them to a depth of 3 in. Let them stand in this for 3 or 4 days, then take them out, drain them in a sieve, and afterwards well wash and rinse them in clean water. Dry on nets having a mesh about the same size as a cabbage net; shake the net occasionally, and the dry feathers will fall through. When they are dried, beat them well to get rid of the dust. It will take about 3 weeks to clean and dry a sufficient quantity for a bed. This process was awarded the prize offered by the Society of Arts.

Firearms.—(1) A good and simple way of cleaning and recolouring the barrels and other metal parts of a double-barrel shot gun which are quite rusty. Take the barrels from the stock, and put them in clean cold water free from gritty matters. Attach the brush to the washing-rod, and get out all adhering powder and residues; next take tow, and wash until the barrels are quite clean. If the parts have rusted, it will be necessary to use a little emery flour. Dry the barrels with clean cotton rags, rubbing until the metal feels warm. Plug the ports and muzzles securely, then cleanse the outside parts with a strong alcoholic solution of caustic potash, aided, if necessary, with a little emery flour and a soft rag. Rinse thoroughly in water, dry thoroughly, warm, and while warm rub over every part with the following preparation: pure (dry) zinc chloride 1 oz., nitrate of antimony ¼ oz., olive-oil 2 oz., well rubbed down into a smooth uniform paste. After ½ hour's exposure, rub off excess of this paste, and polish with clean soft rags. In warming the metal, avoid overheating it so as to injure the temper. (2) In the volunteer service there are several fluids used, which are composed of either turpentine, naphtha, petroleum, benzine, or gasoline, about one-third, or according to fancy, with Rangoon oil. But the instructions to the troops are—a damp rag, flannel or tow, is all that is required to clean the barrel out; if much water is used, it is liable to run into the action. The butt should be raised when washing out. After washing out and drying, an oily rag or flannel to be used. On many occasions the oily material will be found to be efficacious, without the previous use of water. (3) Easy method of cleaning guns and rifles when leaded — If a muzzle-loader, stop up the nipple or communication hole with a little wax, or if a breech-loader, insert a cork in the breech rather tightly; next pour some quicksilver into the barrel, and put another cork in the muzzle, then proceed to roll it up and down the barrel, shaking it about for a few minutes. The mercury and the lead will form an amalgam, and leave the barrel as clean and free from lead as the first day it came out of the shop. The same quicksilver can be used repeatedly by straining it through wash-leather; for the lead will be left behind in the leather, and the quicksilver will be again fit for use. (4) If the barrels have become leaded, wet the tow on the rod with spirits of turpentine, as the latter enjoys the property of removing any leading almost equally with quicksilver. Paraffin will also be found useful where neither of the foregoing can be obtained. Never touch the grooves of a rifle with emery, as it will dull their edges, and, consequently affect the shooting power. ('Land and Water.')

Floors.—(1) Take some clean, sifted, white or silver sand, and scatter it on the floor. Dissolve 1 lb. American potash or pearlash, in 1 pint of water, and sprinkle the sand with this solution. Have a pail of very hot water, and well scrub the boards lengthwise with a hard brush, and use the best mottled soap. Change the water frequently. This is the best way to scour and whiten boards. The potash, if applied as directed, will take out all stains. Ink stains may be removed from boards by using either strong vinegar, or salts of lemon. (2) The following will be found useful in cleaning and restoring colour to woodon floors: 1 part calcinated soda allowed to stand ¾ hour in 1 part slack lime, then add 15 parts water, and boil. Spread the solution, thus obtained, upon the floor with a rag, and, after drying, rub with hard brush and fine sand and water. A solution of 1 part concentrated sulphuric acid and 8 parts water will enliven the wood after above application. When dry, wash and wax the floor.

Fur.—(1) Soap or water will spoil it. Get some clean common whiting—powdered, and plenty of it—put it in a damp place for a day or so, but on no account let it get wet; rub it into the fur with the hand, and don't be afraid to rub it. Now let it stop till next day, give it another good rubbing, then shake out all the whiting you can, and give it a good brushing with a clothes-brush. It will now be pretty clean, except the skin at the bottom of the fur. To remove the dirt from this get the fur over the back of the chair, and use the point of the clothes-brush very briskly, at the same time giving a short puff of wind every time you give a stroke with the brush. With a little patience you will remove every trace of whiting, grease, or dirt. Lastly, pour a little spirits of wine on a plate, dip the point of the clothes-brush in this, and lightly pass it over the fur; move the brush the same way as the fur runs. (2) Take equal parts of flour and powdered salt (which should be well heated in an oven), and thoroughly rub the fur. It should afterwards be well shaken, to free it from the flour and salt. (3) Lay the fur on a table, and rub it well with bran made moist with warm water. Rub until quite dry, and afterwards with dry bran. The wet bran should be put on with flannel, and the dry with a piece of book muslin. (4) Thoroughly sprinkle every part with hot plaster-of-Paris, and brush well with a hard brush. Then beat it with a cane, comb smooth with a wet comb, and press carefully with a warm iron; when dry, shake out all loose plaster-of-Paris. (5) Make a thin paste by adding benzoline to light carbonate of magnesia. Cover the fur with this thoroughly, hang it out in the open air to dry, then shake and brush it, until the whole of the powder has been removed.

Furniture.—*See* POLISHING.

Gilt Mountings.—Gilt mountings, unless carefully cleaned, soon lose their lustre. They should not be rubbed; if slightly tarnished, wipe them off with a piece of Canton flannel, or, what is better, remove them if possible, and wash in a solution of ½ oz. of borax dissolved in 1 lb. of water, and dry them with a soft linen rag; their lustre may be improved by heating them a little, and rubbing with a piece of Canton flannel.

Gilt Picture Frames.—(1) Fly-marks can be cleaned off with soap and water used sparingly on end of finger covered by piece of rag. When all cleared off, rinse with cold water, and dry with chamois leather; next buy a pound of common size, and 2 penny paint pans. Boil a little of the size in one of the pans with as much water as will just cover it. When boiled, strain through muslin into clean pan, and apply thinly to frames with camel-hair brush (called technically a "dabber," and costing 6*d*. to 1*s*. each). Take care you do not give the frames too much water and "elbow grease." On no account use gold size, as it is used only in regilding, and if put on over the gold would make it dull and sticky. (2) Dissolve a very small quantity of salts of tartar in a wine bottle of water, and with a piece of cotton wool soaked in the liquid dab the frames very gently (no rubbing on any account, or you will take off the gilt), then stand up the frames, so that water will drain away from them conveniently, and syringe them with clean water. Care must be taken that the solution is not too strong. (3) If new gold frames are varnished with the best copal varnish, it improves their appearance considerably, and fly-marks can then be washed off carefully with a sponge. The frames also last many times longer. It also improves old frames to varnish them with it. (4) Gilt frames may be cleaned by simply washing them with a small sponge, moistened with hot spirits of wine or oil of turpentine, the sponge only to be sufficiently wet to take off the dirt and fly-marks. They should not afterwards be wiped, but left to dry of themselves. (5) Old ale is a good thing to wash any gilding with, as it acts at once upon the fly-dirt. Apply it with a soft rag; but for the ins and outs of carved work, a brush is necessary; wipe it nearly dry, and don't apply any water. Thus will you leave a thin coat of the glutinous isinglass of the finings on the face of the work, which will prevent the following flies' fæces from fastening to the frame, as they otherwise would do.

Glass. (*See also*, BOTTLES AND DRUGGISTS' UTENSILS.)—(*a*) To clean glass in frames, when the latter are covered or otherwise so finished that water cannot be used, moisten tripoli with brandy, rub it on the glass while moist, and when dry rub off with a silk rag; to prevent the mixture injuring the cloth on the frame, use strips of tin bent to an angle; set these on the frame with one edge on the glass; when the frames are of a character that will not be injured by water, rub the glass with water containing a little liquid ammonia, and polish with moist paper.

Glass Cleaner.—(*b*) 6 lb. prepared chalk, 1⅓ lb. powdered French chalk, 2¼ lb. phosphate calcium, 2¼ lb. quillaia bark, 18 oz. carbonate ammonia, 6 oz. rose pink. Let all the ingredients be in fine powder, mix and pass through a muslin sieve. Directions for use. With soft water make powder into a liquid of the consistence of cream, and apply to the glass by means of a soft rag or sponge, allow it to dry on, wipe off with a cloth, and polish with a chamois leather.

Glass Globes.—Rub inside with a little wet pumice-powder on a cloth, and in 2 minutes you would not know that they were not newly purchased. The best way to cleanse dirty glass of all kinds is to put a small quantity of spirits of salts (hydrochloric acid) into a basin of water, and to place the dirty articles in the liquid for a few minutes, when it will be found that the glass is clean, and only requires drying. If very dirty, the globes may require to stay in the liquid a little longer. This plan is very useful for cleaning the pendant drops of glass chandeliers, water bottles, etc., as no soap is required. Care must be taken not to drop the undiluted spirits of salts on the clothes or hands.

Photographic Glass Plates.—(*a*) One of the most powerful—if not, indeed, *the* most powerful—detergents for refractory plates is the mixture of sulphuric acid and bichromate of potash recommended by Carey Lea some years ago. It is especially useful with glasses which have been frequently used, or which from the nature of the treatment they have undergone resist the action of both acids and alkalies completely. Its utility is dependent upon the powerful action of chromic acid upon organic matter, and we have never yet met with a plate which did not succumb to its treatment. One precaution is necessary in using it, however; it must be carefully removed from the glass by copious washing as soon as possible after it has done its duty. If allowed to soak for some time, as is frequently the practice, the plates appear to absorb the solution (the penetrating power of which is extraordinary), or an insoluble compound becomes firmly attached to the surface and steadfastly refuses to be displaced. Though generally invisible, it results in a peculiar mottled appearance between the glass and the developed film which entirely ruins the picture. We recently treated a number of plates which had become useless from this cause with various detergents, including acids as well as alkalies, but to no purpose; friction with various abrading powders failed to remove the defect, and we were well-nigh compelled to give it up. Remembering, however, that cyanide of potassium has been utilised by carbon printers for the purpose of reducing the strength of overprinted proofs —which it does by virtue of its action upon the insoluble compounds of chromium—we resolved to try its efficacy on our refractory plates, when all the mottling disappeared as if by magic. Those amongst our readers who dare to fly in face of all that has been lately written upon the dangers attending cyanide and bichromate of potash have here a "wrinkle." Surely those who have dared bichromate will not fear the minor dangers of cyanide. ('Brit. Jl. Phot.') (*b*) A cream of tripoli powder and spirits of wine, with a little ammonia added, is a very good solution for cleaning glass plates. Old collodion is also very good; it should be thinned down with an equal bulk of spirits of wine; add an excess of iodide of potassium, and shake till the solution is saturated. Caustic potash is very good; so is carbonate of soda. If the plates be new, and covered with little gritty particles which do not come off on the application of potash, they may be removed with nitric acid. (*c*) Methylated spirits, washleather, and plenty of "elbow grease." (*d*) Dr. Walz takes a dilute solution of permanganate of potash, and pours in enough to wet the sides of the vessel to be cleaned. A film of hydrated manganic oxide is deposited, which is then rinsed with hydrochloric acid. Chlorine is formed which acts in the nascent state on the organic matter, which becomes readily soluble. The permanganate solution can be used again and again till its oxidising power is exhausted. (*e*) Dissolve 15 gr. of iodide of potassium in 5 oz. of water and 5 oz. of alcohol, afterwards adding 3 gr. iodine and enough whiting or rottenstone to make a creamy paste. Rub a little of this on the glass with a rag until clean, then polish with a cloth. (J. Hughes.)

Glass Slides.—"I had tried previously to remove the hardened balsam in many ways, and had succeeded fairly with a mixture of prepared chalk, methylated spirit, and liquid ammonia, but found this objectionable because it was such a dirty job. I now simply warm the slides over a flame, and push off the covers into strong sulphuric acid (oil of vitriol), and leave them therein for a short time; when clean, drain off, and rinse with a little fresh acid, and finish off by washing well in water. As much balsam as possible is removed from the slides by scraping with a knife, and then sulphuric acid is rubbed upon them with a glass rod. They are then well washed. If necessary, a finishing touch may be given with a warm solution of washing soda or methylated spirit and ammonia, to remove all trace of grease. Sulphuric acid should be added to water, or water to sulphuric acid, very gradually." (Thomas H. Powell.)

Paint-Stains on Glass.—(*a*) American potash 3 parts, unslaked lime 1. Lay this on with a stick, letting it remain for some time, and it will remove either tar or paint. (*b*) Common washing soda dissolved in water. Let it soak awhile—if put thick on, say 30 minutes—and then wash off. If it does not remove, give it another application.

Glass Windows.—(*a*) Procure a washleather of convenient size and some "paper-hanger's" canvas. Two yards, divided into three pieces, will be a nice size to work with. Have the cut sides hemmed, and they will last a long while. When it is desired, use one; boil or soak for an hour or so in a solution of soda and water to get out the "dress"; then wring out, and rinse in as many courses of clean water as you like; then partially dry (practice will enable you to judge), fold to a convenient size, and it will be ready for use. The soda solution will now be cool enough for the leather (if too hot it will shrivel the leather); wash in the same manner, and wring superfluous moisture out; then wash the glass thoroughly with it and plenty of elbow grease, and polish off with the canvas. (*b*) A very effective agent in cleaning glass is a dilute solution of fluoric acid. To this is sometimes added a small quantity of some other acid, either sulphuric or hydrochloric. The glass, after being washed with this, must immediately be well washed with clean water. Fluoric acid must be carefully handled, as before dilution it will cause painful sores if allowed to come in contact with the hands and to dry on them. It corrodes glass, which causes its cleansing power, so that the strong acid should not be kept in a glass or glazed bottle or jar, but in a bottle of guttapercha or similar material.

Gloves.—*Kid.*—(1) Make a strong lather with curd soap and warm water; lay the glove flat on a board, the bottom of a dish, or other unyielding surface: dip a piece of flannel in the lather and well rub the glove with it till all the dirt is out, turning it about so as to clean it all over. Dry in the sun or before a moderate fire. When dry they will look like old parchment, and should be gradually pulled out and stretched. (2) Have a small quantity of milk in a cup or saucer, and a piece of brown Windsor or glycerine soap in another saucer. Fold a clean towel or other cloth 3 or 4 times thick, and spread the glove smoothly on the cloth. Dip a piece of flannel in the milk, and rub it well on the soap. Hold the glove firmly with the left hand, and rub it with the flannel towards the fingers. Continue this operation until the glove, if white, appears of a dirty yellow; or, if coloured, until it looks dirty and spoiled, and then lay it to dry. Gloves cleaned by this method will be soft, glossy and elastic. (3) French method: Put the gloves on your hands, and wash them in spirits of turpentine, until they are quite clean, rubbing them exactly as if washing your hands; when finished, hang them in a current of air to dry and to take off the smell of the turpentine. (4) Eau de Javelle, 135 parts; ammonia 8; powdered soap, 200; water, 150. Make a soft paste, and use with a flannel. (5) ¼ lb. white curd soap, ¾ lb. rose-water, 80 gr. powdered borax, 2 oz. spirit of wine. Pare soap and dissolve in rose-water by aid of heat, in a saucepan, adding borax during solution. On cooling add spirit of wine, then pour into tins before it sets too thick. Directions for use. Take a dry flannel and rub a little of the paste on it, rub well on the gloves, when dirt and stains will at once disappear. For grease on cloth it is better to use a damp cloth and rub smartly.

Washleather.—(6) Take out the grease spots by rubbing them with magnesia or with cream of tartar. Then wash them with soap dissolved in water as directed for kid gloves, and afterwards rinse them, first in warm water and then in cold. Dry in the sun, or before the fire.

All gloves are better and more shapely if dried on glove trees or wooden hands.

Gold.—(1) To remove the brown tarnish from coloured gold, take a piece of tissue-paper damped in liq. ammoniæ, gently rub the gold till the tarnish disappears, then wash off carefully with soft brush, soap, and water, dry in sawdust or before the fire; if this is not sufficient, entrust the article to a jeweller. (2) Mix a little rouge and spirits of wine together, and apply to the jewellery with a rather stiff brush, and turn the brush round and round—not to brush as if to polish, but rather tickle it, and pat it with the hair of the brush; but be sure to keep the brush wet with the mixture. After you have got the tarnish off, wash it out with soap and boiling water, and dry in boxwood sawdust. Take care of any stones with foil behind. (3) Rub with a piece of tissue-paper, screwed up and wet with the tongue. This will often do it; if not, re-colour it. (4) A weak solution of cyanide of potassium will clean gold braid. Use with small sponge, and wash off with clean water. Strength, say 10 or 15 gr. to the oz. of water. Care should be taken that the solution does not get into any cuts or wounds, as it is very poisonous. The strength of the solution would greatly depend on the condition of the lace. It can be made stronger if necessary. (5) A solution of 20 dr. chloride of lime, 20 dr. bicarbonate of soda, and 5 dr. common salt, in 5¼ pints distilled water, is prepared and kept in well-closed bottles. The article to be cleaned is allowed to remain a short time in this solution (which is to be heated only in the case of very obstinate dirt), then taken out washed with spirit, and dried in boxwood sawdust. ('Chem. Cent. Blatt.')

Hands.—For cleaning the hands when stained with chemicals: Put ¼ lb. glauber salts, ¼ lb. chloride of lime, 4 oz. of water into a small wide-mouthed bottle, and when required for use pour some of the thick sediment into a saucer and rub it well over the hands with pumice or a nail brush. Stains of nitrate of silver may be removed from the hands by means of a solution of chloride of iron.

Harness. (*And see* LEATHER; *also* HARNESS POLISHES.)—Unbuckle all the parts, and wash clean with soft water, soap, and a brush. A little turpentine or benzine will take off any gummy substance which the soap fails to remove. Then warm the leather, and, as soon as dry on the surface, apply the oil with a paint-brush or a swab. Neat's-foot oil is the best. Hang up the harness in a warm place to dry, but do not let it burn.

Hats.—The stains of grease and paint may be removed from hats by means of turpentine, and if the turpentine leaves a mark finish with a little spirits of wine.

Iron and Steel.—(1) Take a spongy piece of fig-tree wood, and saturate it with a mixture of sweet-oil and finely powdered emery, and with this well rub all the rusty parts. This will not only clean the article, but will at the same time polish it, and so render the use of whiting unnecessary. (2) Bright iron or steel goods (as polished grates and fire-irons) may be preserved from rust in the following manner. Having first been thoroughly cleaned, they should be dusted over with powdered quicklime, and thus left until ready for use. Coils of piano-wire are covered in this manner, and will keep free from rust for many years. (3) Dissolve ½ oz. camphor in 1 lb. hog's lard, and take off the scum; then mix with the lard as much black-lead as will give the mixture an iron colour. Rub the articles all over with this mixture, and let them lie for 24 hours; then dry with a linen cloth, and they will keep clean for months. (4) Table knives which are not in constant use should be put in a case containing a depth of about 8 in. of quicklime. They are to be plunged into this to the top of the blades, but the lime must not touch the handles. (5) Steel bits that are tarnished, but not rusty, can be cleaned with rotten-stone, common hard soap, and a woollen cloth.

Brightening Iron Articles.—(6) When taken from the forge or rolls, the articles are placed in dilute sulphuric acid (1 to 20) for an hour; they are then washed clean in water, dried with sawdust, dipped for a second or so in nitrous acid, washed and dried as before, and finally rubbed clean.

Ivory and Bones. (*And see* BLEACHING.)—(1) Spirits of turpentine is very efficacious in removing the disagreeable colour and fatty emanations of bones or ivory, while it leaves them beautifully bleached. The articles should be exposed in the fluid for 3 or 4 days in the sun, or a little longer if in the shade. They should rest upon strips of zinc, so as to be a fraction of an inch above the bottom of the glass vessel employed. The turpentine acts as an oxidising agent, and the product of the combustion is an acid liquor which sinks to the bottom, and strongly attacks the ivory, if allowed to touch it. (2) Make a thick puddle of common whiting in a saucer. Brush well with a tooth-brush into the carved work. Brush well out with plenty of clean water. Dry gently near the fire. Finish with a clean dry hard brush, adding one or two drops (not more) of sweet oil. (3) Mix about a tablespoonful of oxalic acid in ½ pint of boiling water. Wet the ivory over first with water, then with a tooth-brush apply the acid, doing one side at a time, and rinsing; finally drying it in a cloth before the fire, but not too close. (4) Take a piece of fresh lime, slake it by sprinkling it with water, then mix into a paste, which apply by means of a soft brush, brushing well into the interstices of the carving; next set by in a warm place till perfectly dry, after which take another soft brush and remove the lime. Should it still remain discoloured, repeat the process, but be careful neither to make it too wet nor too hot in drying off, or the article may come to pieces, if glued or cemented together. If it would stand steeping in lime-water for 24 hours, and afterwards boiling in strong alum-water for about an hour and then dried, it would turn out white and clean. Rubbing with oxide of tin (putty powder) and a chamois leather, will restore a fine gloss afterwards. (5) Well clean with spirits of wine, then mix some whiting with a little of the spirits, to form a paste, and well brush with it. It is best to use a rubber of soft leather where there are no delicate points; put a little soap on the leather, and dip into the paste, and rub the ivory until you get a brilliant polish, finish off with a little dry whiting; the leather should be attached to a flat wood surface, and rub briskly. (6) When ivory ornaments get yellow or dusky-looking, wash them well in soap and water, with a small brush to clean the carvings, and place them while wet in full sunshine under a glass cover; wet them two or three times a day for several days, with soapy water, still keeping them in the sun; then wash them again, and they will be beautifully white. The glass cover is essential as without it the surface will be covered with fine cracks. To bleach ivory, immerse it for a short time in water containing a little sulphurous acid, chloride of lime, or chlorine.

Jewellery.—Common jewellery may be effectually cleaned by washing with soap and warm water, rinsing in cold water, dipping in spirits of any kind, and drying in warm *boxwood* sawdust. Good jewellery only needs washing with soap and water, and polishing with rouge and a chamois leather.

To Restore the Lustre of Jewellery.—Take 1 oz. cyanide potassium and dissolve in 3 gills water. Attach the article to be cleansed to a wire hook, immerse and shake in the solution for a second or two, and remove and wash in clean water, then in warm water and soap. Rinse again, dip in spirits of wine, and dry in boxwood sawdust. If the solution is kept, put it in a tightly-corked bottle, and label poison conspicuously. One caution is necessary: do not bend over the solution so as to inhale the odour, nor dip the fingers in it; if one of the articles drops from the hook, better empty the solution into another vessel.

Lacquered Metal Articles.—*See* BRASS.

Leather.—(1) Carriage tops that have faded and become grey can be restored by washing with a solution composed of 4 oz. of nut galls, 1 oz. each of logwood, copperas, clean iron filings, and sumach berries; put all but the iron filings and copperas in 1 qt. of the best white wine vinegar, and heat nearly to the boiling-point; then add the copperas and iron filings; let them stand for 24 hours, and strain off the liquid; apply with a sponge. This is equally good for restoring black cloths. (2) Enamelled leather tops that have been soiled by dust and rain should be washed with soft water and Castile or crown soap. Apply the water with a sponge and then scrub with a moderately stiff brush; cleanse with clean water, and dry with a "shammy." Never apply any kind of oil or top dressing without first cleaning the leather. (3) To clean mouldy leather remove the surface mould with a dry cloth, and with another cloth apply pyroligneous acid. (4) To clean russet leather-covered mountings, remove all stains and dirt by rubbing the leather with a cloth and a little oxalic acid, and restore the colour and finish by the use of salts of lemon, applied with a woollen cloth. Rub the leather until a good polish is produced. (5) To clean rubber-covered mountings, rub the covered as well as the metallic parts with a "shammy" and a little tripoli, and finish with a clean woollen cloth. (6) To clean a soiled chamois-leather, make a solution of weak soda and warm water, rub plenty of soft soap into the leather, and allow it to remain in soak for 2 hours, then rub it well until it is quite clean. Afterwards rinse it well in a weak solution composed of warm water, soda, and yellow soap. If rinsed in water only, it becomes hard when dry and unfit for use. The small quantity of soap used in the leather allows the finer particles of the leather to separate and become soft like silk. After rinsing, wring it well in a rough towel, and dry quickly; then pull it about, and brush it well, and it will become softer and better than most new leathers. (7) To clean morocco leather, strain well over a board, and scour with stiff brush, using tepid water and soft soap, made slightly acid with oxalic acid; when done unstrain the leather; and dry in a cool place; do not saturate the leather, but keep the board inclined; when dry, rub a little oil lightly over the surface with a rag. (8) To clean riding saddles. If much soiled, wash the leather with a weak solution of oxalic acid and water, and, when dry, with the watery portion of beef blood. The latter can be preserved by adding a little carbolic acid, and keeping it in a bottle tightly corked. (9) Brown saddles may be cleaned to look as well as new by the use of tepid water and crown soap; if the latter cannot be had, use pure Castile soap.

Marble.—(1) Take finely powdered pumice-stone and vinegar, wash the surface with the mixture, and leave it for several hours, then brush it hard and wash it clean. When dry, rub it with whiting and washleather. (2) Equal parts of caustic potash, quicklime, and soft soap; make into a thick paste with water, and apply with a brush; leave for about a week, and apply again and again until the stain has disappeared. (3) Common soda, 2 parts; pumice stone (pulverised), 1; finely powdered chalk, 1. Sift through a fine sieve, and mix with water. Rub all over the marble until the stains are removed. Then wash the stone with soap and water. Marble that is yellow with age, or covered with green fungoid patches, may be rendered white by first washing it with a solution of permanganate of potash of moderate strength, and while yet moist with this solution, rubbing with a cloth saturated with oxalic acid. As soon as the portion of the stone operated upon becomes white, it should be thoroughly washed with pure water to remove all traces of the acid. (4) Wash the marble thoroughly with soda and warm water to remove any grease, and apply oxalic acid by laying a piece of white cotton cloth saturated upon the spots for a short time. If it destroys the polish, repolish with oxide of tin and water applied with a cloth. If the stains are not deep, rub the surface only with the oxalic acid and water upon a small piece of cloth quickly, and wash to free the marble of acid. Then, to give it a gloss, rub with chalk wet with water. (5) Take a bullock's gall, 1 gill of soap lees, half a gill of turpentine; make into a paste with pipe-clay, apply it to the marble; let it dry a day or two, then rub it off, and it will appear equal to new; if very dirty, repeat the application. (6) Mix up a quantity of the strongest soap-lees with quicklime, to the consistence of milk, and lay it on the stone for twenty-four hours; clean it afterwards, and it will appear as new. This may be improved by rubbing afterwards with fine putty powder and olive-oil.

Mildew, To remove.—Make a very weak solution of chloride of lime in water (about a heaping teaspoonful to a quart of water), strain it carefully, and dip the spot on the garment into it; and if the mildew does not disappear immediately, lay it in the sun for a few minutes, or dip it again into the lime-water. The work is effectually and speedily done, and the chloride of lime neither rots the cloth nor removes delicate colours, when sufficiently diluted and the articles rinsed afterward in clear water.

Mirrors.—(1) Wet the surface of the glass with gin, to remove the stains. Then rub with a cloth dipped in powdered blue. Polish with a silk handkerchief. Be very careful not to touch the frames. (2) Very soft paper is much better than cloth.

Oilcloth.—Wash with a large, soft, woollen cloth and lukewarm or cold water, dry thoroughly with a soft cloth, and afterwards polish with milk, or a weak solution of beeswax, in spirits of turpentine. Care must be observed in using a brush, as not all oilcloths or linoleums will stand it, yet there occur instances in which floor-cloths, particularly linoleums, get dirt worked into them, if the cloth washing is not well done, and then not only is a brush needed but also a strong soap or soap-powder (soap extract), and if only used occasionally, the floor-cloth does not appear to suffer from it. The cleaning that these goods will bear depends greatly on the quality.

Paint.—(1) Dissolve ¼ oz. glue, and a bit of soft-soap the size of a walnut, in about 3 pints of warm water, and with a well-worn whitewash brush well scrub the work, but not sufficient to get off the paint, and rinse with plenty of cold clean water, using a washleather; let it dry itself. Work done in this manner will often look equal to new. (2) First take off all the dust with a soft brush and pair of bellows. Scour with a mixture of soft soap and fullers' earth, and use lukewarm water. If there are any spots which are extra dirty, first remove these by rubbing with a sponge dipped in soap and water. Commence the scouring at the top of the door or wainscot and proceed downwards; and dry with a soft linen cloth. When cleaning paint it is always better to employ two persons, one to scour and the other to rub dry. (3) Dip a flannel rag into warm water, and wring it out nearly dry. Take up on the rag as much whiting as will adhere, and rub this on the paint until the dirt or grease disappears. Wash the part well with clean water, and rub dry with soft cloth. This is an excellent and clean method, and is often effective in removing discoloration from white or light-tinted paints and enamels, and varnished work.

Paint-brushes. — To soften brushes that have become hard, soak them 24 hours in raw linseed-oil, and rinse them out in hot turpentine, repeating the process till clean; or wash them in hot soda and water and soft-soap.

Paintings.—(1) Dissolve a little common soda in urine, then add a grated potato and a little salt; well rub this over the paintings till clean. Wash off in spring water, and dry with a clean cloth. (2) First rub the picture well with good whisky, which will make the varnish come off in froth, then wash well with cold water, and when dry varnish again; this will restore the picture to its original colour unless very old. Keep the picture covered from dust till the varnish is dry.

(3) Elfred Blaker's process of restoring oil paintings may be divided into 4 heads : (*a*) Lining, (*b*) Stopping, (*c*) Cleaning, (*d*) Stippling or restoring proper.

Lining.—A strong wooden frame, called a "stretcher," is made of stout "quartering" of the size required, and fitted with wedges (as in ordinary) canvas "strainers"), by means of which the frame may be slightly extended so as to tighten or stretch a layer of canvas spread over and secured to it by means of tacks. Take ordinary pictureliner's canvas, several inches wider each way than the picture to be lined, and tack it on to the frame. The canvas being strained or stretched, the back of the picture is carefully brushed over with a mixture composed of glue and "size," the face of the canvas being also brushed over with the same mixture. The picture is next laid back downward on the canvas, beginning at one corner and gently pressing it with the hand so as to disperse air-bubbles. The canvas is tightened by driving in the wedges at each corner of the stretcher. Take as many sheets of double-crown paper as will cover the entire picture (allowing each sheet to overlap the other about 1 in.) ; brush paste over one side of each sheet and fold separately. When the required number of sheets of paper have been thus prepared, take the first sheet, open it, and lay it carefully on the picture, beginning at one corner, and press it as before with the hand so as to remove air-bubbles. Each sheet is to be laid on in the same way until the entire picture is covered. After being left for a time, and when the paper is dry, the picture is subjected to pressure from a heavy heated iron, somewhat resembling a tailor's goose. For this purpose a perfectly smooth board, equal in thickness to the timber with which the stretching frame is made, is placed beneath the picture, at one corner, and the heated iron (the temperature of which must not be too high) is thus applied with steadiness and care, the pressing-board being shifted (when a large picture is under treatment) until the whole surface of the picture is well pressed. When the canvas is perfectly dry, the paper is removed by a sponge and warm water. When all traces of paper and paste are removed from the surface of the picture, the latter is removed from the rough stretcher, the canvas neatly trimmed, leaving sufficient margin to attach it to a new strainer of a size suitable to the picture ; the canvas margin is then tacked on to the edge of the frame in the usual way, after which the wedges are driven tight.

Stopping.—The object of this operation is to fill all fissures or cracks in the picture with a composition which is capable of receiving a coating of paint without absorbing it. The composition employed for this purpose consists of a mixture of size and whiting, to which a small quantity of black is added to give the composition a neutral tint. The "stopping," as this mixture is called, is pressed into the cracks by means of a palette-knife, care being taken that every fissure is well filled with it. The picture must now be set aside for several days to allow the stopping to become gradually but thoroughly dry. The next operation is to remove the superfluous stopping, which is effected by rubbing the surface of the picture with soft or "velvet" cork moistened with water. The cork must be applied gently and with a circular motion, so that, while removing the superfluity, the cracks may be left perfectly level.

Cleaning. — This term is applied technically to the removal of varnish from old pictures, and it is scarcely necessary to say that if this were attempted by means of chemical solvents of gum-resins, which form the basis of most varnishes, old or new, the operation would be very hazardous in skilful hands, while in those of an ignoramus the underlying picture would (as has frequently been the case) be sacrificed, by the solvent (turpentine, for example), after attacking the varnish, performing the function of dissolving the oil of the picture. This barbarous application of varnish solvents has acquired the appropriate name of "skinning," a term which implies the removal not only of the varnish, but the picture itself. Although it is possible by means of chemical solvents to remove coats of varnish from the surface of oil paintings, the plan adopted by Blaker is by far the most safe, and in practical hands the most secure. It consists in rubbing the varnished surface gently with the finger, by which the resinous matter works up into a powdery condition, and this action is kept up with great care until the colours of the picture, as will be readily understood, become exposed to view.

Restoring.—When it is borne in mind that the varied tints and colours employed by the old masters (and many of which are of doubtful origin at the present day) require to be faithfully matched, it will be understood that only an artist of great skill and experience, possessing an extensive knowledge of the productions of the old painters, should be entrusted with the delicate operation of renovating, without spoiling, works of olden time. The process called "stippling" is adopted for matching the various colours and tints, very small brushes being employed, and each brush being reserved for its special use with great care, in order to avoid even the most trifling risk of mismatching any required tint. When the stippling has thus been done by an artist possessing knowledge and experience, as well as natural ability (the two first-named attributes being the most essential), the picture, when "restored," and subsequently varnished, presents the appearance of a perfect picture, the touches of the restorer being imperceptible. Before the picture is varnished, strips of white paper about 1½ in. wide are neatly pasted round the edge of the frame, and overlapping the picture about ½ in., so as to leave a neat but scarcely perceptible margin. The varnishing of oil paintings is more properly effected by skill than by rule of thumb. The operation should be conducted in a warm room, perfectly free from dust. The picture should be laid flat on a level bench, and a small quantity of varnish poured on its centre; a flat soft brush is then taken, and with this the varnish is brushed over the surface, care being taken to avoid "brush-marks." The picture is then allowed to remain in its horizontal position until the varnish is thoroughly dry.

(4) The following are Pettenkofer's theory and modes of operation: Linoleine (the linoxide of Mulder) is the principle of the greater portion of the oils used by artists, but, unfortunately, this principle cannot be prepared in a pure state, and painters are compelled to employ either linseed-oil, which contains 80 per cent. of linoleine, or poppy oil, which only contains 75 per cent. Linoleine, which, when pure, is liquid, solidifies by oxidation, on contact with the air, without decrease in volume, but with an increase of 10 per cent. in weight. It is because linoleine acquires an unvariable consistency in any temperature that colours, after a picture is dry, are not affected by moderate pressure, by fatty or ethereal oils, nor by varnishes. Paintings absorb moisture from the atmosphere, and afterwards allow it to evaporate. After a longer or shorter period when these successive absorptions and evaporations of moisture have been pretty often repeated, the colour laid on by the artist generally has lost its primitive aspect, and ceases to produce the same optical effect.

As to the means employed previous to the discoveries of Pettenkofer for the regeneration of the physical condition of the colours, it must be remembered that the artist himself varnishes his dry picture to fill up the pores which during the work contained oil, but which after the picture is dry contain only air and varnish. He employs resinous oil, solutions of resin in essence of turpentine or in fatty and drying oils. These last are very dangerous. After a certain time the varnish perishes, and no longer allows the light to pass through it; new varnish is applied and the operation is repeated, unfortunately, until all brilliancy is destroyed. To repair the evil, there are no other means but the removal of the varnish, the nourishing of the colour with a fresh coat of oil, and, after drying, to apply a new coat of varnish, to say nothing of brushwork. When the restoration is made by moistening the varnish with water, the effect after drying is a white spot wherever the water has been applied.

Pettenkofer has shown that paintings are constantly liable to those successive condensations and evaporations mentioned above, which cause loss of cohesion of the varnish. He has, moreover, succeeded in re-establishing the molecular cohesion by means of the vapour of alcohol mixed with the air; at the end of 48 hours the resin takes up and condenses 80 to 100 per cent. of its own weight of alcohol, which, however, it loses again after a short time. The resin, thus softened, becomes absorbed by the painting, and by the same act the cohesion of the resin and the colour is re-established. Softened resin has less effect on the colours of a painting than varnish applied with a brush, for the friction of the latter may cause displacement of the colouring bodies.

Pettenkofer's plan is simple; in the first place he makes a small experiment on the painting to be restored, by means of a small round box made of cardboard, the inside of which is dressed with glue, and the bottom lined with flannel moistened with alcohol at 80°; the picture is freed from dust, and the box turned down upon a part of it. The spot thus restored serves as a guide for the general restoration of the work, which is done by fixing the picture to the lid of a box, the bottoms and sides of which are lined with flannel moistened with pure alcohol, as above described, and shutting very closely, so that a small quantity of alcohol serves for a series of pictures.

A second method, indicated by Pettenkofer, consists in the use of the balsam of copaiba, which dries very slowly, and which resembles in constitution the varnishes composed of dammar or mastic dissolved in essence of turpentine. The copaiba should have the consistency of unboiled oil, but must not contain oil, resin, or essence of turpentine. The essential oil of the balsam of copaiba is less volatile in ordinary temperatures than the essence of turpentine. The balsam of copaiba fulfils well the optical conditions of the ordinary resinous varnishes, and may be applied to certain parts only of a picture without being perceptible; it fills up the pores which have been produced in the coloured parts, and sometimes this object may even be effected by applying the balsam to the back of the canvas. The application of copaiba and the vapours of alcohol has in many cases to be repeated several times, and they may cause the appearance of cracks previously invisible, in which case it is only necessary to rub them with a small quantity of the balsam, and expose them to the vapour of alcohol.

If there be an excess of resin, and above all, if the pictures become too yellow in tone, it is absolutely necessary, unfortunately, to remove that excess, but without injuring the primitive character of the colour, before commencing the restoration proper. The varnish, however, can never be entirely removed without some slight deterioration of colour, because the resin is not only superposed but incorporated with the colour.

To remove the excess of resin, either rub with the finger dipped in powder of colophony, or dissolve it with essence of turpentine; and, on the other hand, to fill the pores of the picture with resin, first wash with water, and then with essence of turpentine, and having nourished it, as it were, with balsam of copaiba, the part is made to swell by the application of vapour of alcohol.

If the picture contain both resinous and oil varnishes, the former alone takes up alcohol, becomes softened and retires into the colours, while the latter remains on the surface, and renders it dull and even rough. In this case only the balsam of copaiba is used, and smoothness of surface is obtained by pressure.

A painting regenerated by means of balsam of copaiba resists for a long time the influence of the condensation and evaporation of humidity.

(5) A correspondent of the Philadelphia 'Evening Bulletin' has taken the pains to find out how the galleries and the pictures in the Louvre are kept clean. On Mondays the palace is closed; it is then that the weekly cleaning takes place. The first thing done is to cover the floor with damp sawdust to the depth of an inch or so. Oak sawdust is used for the boards, and elm sawdust for the marbles. This is allowed to remain some time, and is then removed, and with it goes every particle of dust or dirt which may have adhered to the floor. Then the men buckle on to their feet large stiff brushes, and armed with a stout stick, to one end of which is fastened a great piece of prepared beeswax, they first rub the floor with wax, then skate over it with their brushes, and finally give it the finishing polish with a great woollen cloth made expressly for this purpose. The same cloth is passed daily over the floor before the opening of the museum, which is all that is required until the following Monday. In this way no dust arises, and the pictures need rarely to be cleaned. When this becomes necessary, which happens about once in 4 or 5 years, the museum is closed for several days. No one is allowed to touch a picture unless the "Conservateur du Musée" be present. The pictures are taken down, and it is the "Conservateur" himself who places a thick sheet of clean wadding over the painting, pressing it down gently in such a way that every particle of dust adheres to the wadding. After this is done, a thin coat of oil or some mixture which replaces it is rubbed on, and the picture is not again touched until the next general house cleaning. (6) Dissolve a small quantity of salt in stale urine; dip a woollen cloth in the mixture, and rub the paintings over with it till they are clean; then wash them with a sponge and clean water; dry them gradually, and rub them over with a clean cloth. Should the dirt be not easily removed by the above preparation, add a small quantity of soft soap. Be very careful not to rub the paintings too hard. (7) The blackened lights of old pictures may be instantly restored to their original hue by touching them with deutoxide of hydrogen diluted with six or eight times its weight of water. The part must be afterwards washed with a clean sponge and water.

Parchment.—Immerse the parchment in a solution of acetic acid, and gently rub the stained parts while wet on a flat board with lump pumice, then bleach it with chloride of lime. This process was recommended in the 'English Mechanic.' It is not very successful, but it makes it white enough for bookbinding. It has, however, the objectionable qualities of not making the parchment flexible, and when dried it is as hard as a board, and it has no gloss like the virgin parchment. On no account must the parchment be washed in very hot water, or held before a fire, as it will shrivel up in a most provoking manner.

Pearls.—Soak them in hot water in which bran has been boiled, with a little salts of tartar and alum, rubbing gently between the hands when the heat will admit of it. When the water is cold, renew the application till any discoloration is removed, rinse in lukewarm water; lay them on white paper in a dark place to cool.

Sheepskin Mats.—Wash while fresh in strong soapsuds, first picking from the wool all the dirt that will come out. A little paraffin, 1 tablespoonful to 3 gal. water, will aid in removing the impurities. Continue to wash the skin in fresh suds till it is white and clean. Then dissolve ½ lb. each of salt and alum in 3 pints boiling water, put into it water enough to cover the skin, which should soak in the solution 12 hours, and then be hung on a line to drain. When nearly dry, nail it, wool side in, on a board, or the side of a barn, to dry. Rub into the skin 1 oz. each of pulverised alum and saltpetre, and if the skin is large double the quantity. Rub for an hour or two. Fold the skin sides together, and hang the skin away for 3 days, rubbing it every day or till perfectly dry. Then with blunt knife clear the skin of impurities, rub it with pumice or rottenstone, trim it into shape, and you have a door mat that will last a life-time. If it is to be dyed, have a shallow vessel as large as the skin in which to prepare the dye, so that the skin can be laid wool-side down smoothly into the vessel that all parts may be equally immersed in the dye. This should not be more than an inch deep, otherwise the skin might be injured by the hot dye. After colouring, again stretch the skin to dry, and then comb with a wool or cotton-card.

Silver. (*And see* SILVER PLATING, SILVERING SOLUTIONS, ETC.)—(1) East Indian jewellers never touch silver ware with any abrasive substance, but use, instead of polishing paste, etc., slices of lemons; the goods to be cleaned are well rubbed with these, and then left in a pan for a few hours, covered with slices. For delicate jewellery, a large lime is cut in half, the article inserted, the two halves applied together and tied up for some hours; the article is then washed in several waters, placed in a pan of nearly boiling soapsuds, stirred about, rinsed, and dried on a metal plate, the smooth parts being gently rubbed with washleather, if required. Cyanide of potassium solution (rather weak) dissolves off the dirty surface gradually, but great care is required. Green tamarind pods (oxalate of potash) are greater detergents for gold and silver than lemons, and are often employed for the purpose of removing stains, fire-marks, etc. ('Boston Journal of Chemistry.') (2) Elsner states that a polish equal to that obtained by the use of the finest plate powder, can be produced by simply cleaning the silver in water in which potatoes have been boiled. (3) Dead or engraved silver goods should never be cleaned with plate powder, but be washed out with a soft brush and some strong alkali, and well rinsed afterwards. When the dead or frosted parts are quite dry, the polished parts are carefully cleaned with powder. (4) The following directions are given by a silversmith in Christiania: Silver filigree work is best cleaned by the application of spirit of ammonia by means of a soft brush, and afterwards thoroughly washing in soft-soap and warm water, and rinsing in clean warm water, and quick drying by linen rags, blotting-paper, or some similar clean absorbent. Should this method, after several repetitions, cease to have the required effect, the article will have to be sent to a silversmith to be heated and boiled in acid. The best mode of preservation is to wrap the article in tissue paper before placing it in the case. (5) The simplest and cleanest substance for cleaning silver articles is, according to Professor Davenport, hyposulphite of soda. It acts quickly, and is inexpensive. A rag or a brush, moistened with a saturated solution of the salt, cleanses even strongly oxidised silver surfaces in a few seconds, without the application of any polishing powder. (6) Mix 8 oz. prepared chalk, 2 oz. turpentine, 1 oz. alcohol, 4 dr. spirits of camphor, and 2 dr. liquor of ammonia. Apply this mixture to the article with a sponge, and allow to dry before polishing. (7) Dissolve 12 oz. cyanide of potassium in 1 qt. of water; dip the silver in this solution, and brush it with a stiff brush until clean, then wash and dry.

(8) Tarnished silver lace. Sponge over with a weak solution of potassium cyanide. (9) Dab over with a cream of heavy magnesia and water, allowing this to dry, and then brushing it off with a soft-haired brush. (10) Take an ounce each of cream of tartar, muriate of soda, and alum, and boil in a gallon or more of water. After the plate is taken out and rubbed dry, it puts on a beautiful silvery whiteness. Powdered magnesia may be used dry for articles slightly tarnished, but if very dirty it must be used first wet and then dry. (11) Ordinary petroleum or paraffin will remove the hard blackened surface of old dirty silver goods, and is useful in dealing with goods of intricate design which cannot be rubbed. After soaking the silver in petroleum about an hour, the blackened surface will come off at the least touch. A soft brush can be used, after which use plenty of dry whiting to absorb any remaining oil and to remove the odour. (12) *Silvered dial-plates.* Silvered dial-plates of clocks frequently lose their lustre by the effect of air and smoke or sulphurous emanations. To cleanse them make pulverised purified tartar into a paste with water. Take some of the paste on a brush of bristles, and rub the dial-plate, turning it constantly until the silvering has acquired its original whiteness and lustre. Then wash the dial-plate with clean water, and dry by gently patting with a cloth. Finally expose to a moderate heat. (13) Pickle for frosting and whitening silver goods. Sulphuric acid, 1 dr.; water, 4 oz.; heat the pickle, and immerse the silver in until frosted as desired; then wash off clean, and dry with a soft linen cloth, or in fine clean sawdust. For whitening only, a smaller proportion of acid may be used.

Sponge.—(1) To clean any sponge that has got into a greasy gelatinous condition, a solution of permanganate of potash in water is prepared of such a strength that it appears of a wine colour, and into this the unserviceable sponge is immersed, and allowed to remain for some time. When taken out and squeezed, it is next put into a diluted muriatic acid of ordinary commercial quality, being immersed and kept saturated therein for some time as before. The most appropriate strength of this acid solution is about 10 parts water to 1 of acid. The sponge is taken out after sufficient treatment, squeezed well to free it from the acid, and then washed well in good spring water. When taken out, it will be found to be quite clean, to have again assumed its light colour, and to be free from all foreign matter. Sponges treated in this way become like new sponges, and can be used without any fear of their contaminating, even if employed for the filtration of neutral liquids. The main thing to be attended to in this plan of purifying sponge is to see that it is thoroughly saturated both by the permanganate and the acid solutions, which should be allowed ample time to soak through the mass; care must also be observed to wash the sponges thoroughly with plenty of water at the end of the operation. (Dr. J. Stinde.) (2) When sponges get greasy, let them dry, and then work them with a small quantity of turpentine, and after a few minutes wash them with warm soap-and-water with a little bit of soda. This will get them quite clean with very little trouble. (E. T. Scott.) (3) Put a handful of salt on the sponge, and rinse the salt well through the sponge. Let the sponge dry in a thorough draught of air. The latter precaution alone will keep sponges free from sliminess, unless they become saturated with soap. (4) I tried the effect of sulphuric acid as follows: In a large basin mixed about a pint of water and two table-spoonfuls of sulphuric acid (common oil of vitriol), then steeped the sponge about 2 hours, wrung it out several times in the acid, and finally well washed out the acid in clean water; it was then just like new, having regained its former size, colour, and elasticity, with not the slightest trace of its former sliminess. It was a large bath-sponge, and in an extremely bad condition. (J. W. Jackson.) (5) Dissolve some citric acid in water in a hand-basin, and wash the sponge in it as in (4).

Stains, removing (*and see* CLOTH, *and* TEXTILE FABRICS).—The following general remarks on the removal of stains appeared anonymously in the 'English Mechanic.' To proceed with any degree of certainty in endeavours to remove stains, they must be divided into three classes, as each variety will require a peculiar treatment. The first class comprehends those stains which do not in any way affect the nature of the material or colour, but simply alter its appearance, and which can be removed by the application of one agent alone. These may be designated Simple Stains. The second divison includes such as are produced by two or more substances conjointly, and which consequently require the employment of several cleaning agents. These are known as Mixed Stains. In the third category may be placed such stains as are produced by bodies which alter or destroy the colour.

In the first class are *water*, *oily matters*, *vegetable juices*, *blood*, and *iron* or *ink* stains. If water be allowed to fall on some kinds of silks, satins, or woollen fabrics, it dissolves away part of the dressing, and the consequence is that a dull spot appears on the glossy ground. To remove a stain of this nature, it is necessary to steam the spotted material until it is all equally moistened. It may then be hot-pressed, or, if small, ironed with a hot, but perfectly clean iron.

Grease spots may generally be removed from the most delicate material by the employment of benzine or oil of turpentine, care being taken that sufficient be employed to remove all line of demarcation. Ox-gall is particularly useful in extracting grease stains from woollen goods. If the stain be very thickly crusted and old, it may be sometimes advantageous to soften the grease (previous to the application of benzine) by means of a warm iron laid on a piece of thick blotting-paper which has been placed over the spot.

Tar and *pitch* produce stains easily removed by successive applications of spirits of turpentine, coal-tar naphtha, and benzine. If they are very old and hard, it is as well to soften them by lightly rubbing with a pledget of wool dipped in good olive-oil. The softened mass will then easily yield to the action of the other solvents.

Resins, *varnishes*, and *sealing-wax* may be removed by warming and applying strong methylated spirits. Care must always be taken that, in rubbing the material to remove the stains, the friction should always be applied the way of the stuff, and not indifferently backwards and forwards.

Most *fruits* yield *juices* which, owing to the acid they contain, permanently injure the tone of the dye; but the greater part may be removed without leaving a stain, if the spot be rinsed in cold water in which a few drops of liquor ammonia have been placed *before the spot has dried*. *Wine* also leaves an ugly stain on white materials; from these it may be removed by rinsing with cold water, applying locally a weak solution of chloride of lime, and again rinsing in an abundance of water. The dressing must again be imparted by steaming, starching, and hot-pressing.

Fresh *ink* and the soluble salts of *iron*—such as are used by photographers in their developing solutions, etc.—produce stains, which, if allowed to dry, and especially if afterwards the material has been washed, are difficult to extract without injury to the ground. When fresh, such stains yield rapidly to a treatment with moistened cream of tartar, aided by a little friction, if the material or colour is delicate. If the ground be white, oxalic acid, employed in the form of concentrated aqueous solution, will effectually remove fresh iron stains. *Acids* produce red stains, on blacks, blues, and violets, made from the vegetable colours (except indigo). If the acid has not been strong enough to destroy the material, and the stains are fresh, the colour may generally be restored by repeated soakings in dilute liquor ammonia, applied as locally as possible. Photographers frequently stain their clothes and cloths with *nitrate of silver*. The immediate and repeated application of a very weak solution of cyanide of potassium (accompanied by thorough rinsings in clean water) will generally remove these without injury to the colours.

Mixed stains are generally produced by spilling sauces, gravy, or, by inadvertently rubbing against wet paint, cart-grease, etc. *Sauce* usually contains oily or greasy matter, blood and vinegar, or some fruit-juice; hence the first step consists in removing the grease by means of ox-gall or benzine, then the acid of the vinegar or juice is neutralised by means of weak ammonia, when a final rinse in cold water will extract the blood, etc.

Most *fruit-juices*, *wines*, *jam*, etc., leave stains that will require a preliminary washing with water, to remove sugary matter, treatment with very dilute ammonia to neutralise the acid, and exposure while damp to the fumes of burning sulphur. But the action of this agent must be localised as much as possible to the spot where the stain occurs, and it must be used with the greatest circumspection, for it bleaches nearly all vegetable colours, though many of them regain their force on exposure to air.

Paint stains may be treated with oil of turpentine to remove the oil, with oxygenated water to oxidise the lead, and finally, with dilute acetic acid. If the paint contains oxide of iron, oxalic acid will have to be used, while the copper colours must be treated with liquor ammonia.

Old *ink* stains require treating first with protochloride of tin, to deoxidise the iron, and then with dilute oxalic acid. If the material be white, it may be touched with a dilute solution of chloride of lime on the part stained, and then thoroughly washed.

Lubricants generally contain, besides grease, oxide of iron worn off the machinery, etc., hence the grease must first be extracted by means of benzine, ox-gall, ammonia, etc., and then the spot treated with oxalic acid or chloride of lime water, or even lemon-juice, if the material is very delicate. Rinsing must always follow the application of these agents.

Mercurial ointment produces very persistent stains. These may be extracted by washing the spot with a hot solution of soda (1 soda to 50 water), and when the grease is removed, by rubbing over with a rather strong solution (clear) of chloride of lime. Benzine must be substituted for the soda solution if the article is coloured or delicate.

Care must be taken in all these cases to operate on both sides of the stuff, or the removal will only be superficial, and the spot will reappear in time. It will be seldom found, in the case of mixed stains, that the original tone of the colour is not more or less altered or injured. Consequently, attempts must be made to re-establish the colours. If the colours be aniline, the application of Judson's dyes, in a dilute form, will generally be efficacious, except on cottons, which will require a previous mordanting on the spot. This may be effected by means of a strong decoction (clear) of myrobalams.

If the colours have been changed by vegetable acids, or dilute mineral acids, the colour may generally be restored by means of dilute ammonia. If that does not suffice, the spot must be mordanted with a brush, and the dye painted in. While drying, the spot must be continuously rubbed with a pledget of wool dipped in ether, so as to spread the matter equally, and leave no sharp line of demarcation. A weak solution of sulphate of indigo will be found useful for restoring blues; the strength must naturally be proportioned to the depth of tone required. Most scarlets, crimson, etc., can be restored by the application of a solution of bichloride of tin, followed, if necessary, by a local application of tincture of cochineal. If crimson be required, a small portion of alum must be added ; if scarlet, cream of tartar along with the cochineal.

The stains produced by fresh *urine*, and by *perspiration*, require to be treated first with weak ammonia, and then with the bichloride of tin solution (long known as eau écarlate), which will, if the colour be not altogether destroyed, restore it. Painting in, after the application of the appropriate mordant, is the only remedy, if the colour has suffered permanently.

Aniline Colours.—(1) Goods stained with aniline colours may be rendered clean by the use of zinc grey : the metallic zinc contained in this powder reduces the colours, forming soluble colourless products. Triturate 100 gr. zinc grey with 50 gr. mucilage, 20° B., until the mixture is homogeneous ; incorporate with this 20 gr. of a solution of hyposulphite of soda, 20° B., apply this mixture directly to the goods ; let it dry and vaporise. After this operation it is best to wash the goods with water slightly acidulated with hydrochloric acid. (2) White cottons and linens, tartaric acid in solution ; the older the stain the more concentrated the solution should be. Coloured cottons and woollens and silks, a weak solution of tartaric acid, if the colour allows of its use. (3) Stains of red aniline may be removed by moistening the spot with strong alcohol acidulated with nitric acid. Unless the stain is produced by eosine it disappears without difficulty. Paper is hardly affected by the process ; still it is always advisable to make a blank experiment first.

Fruit and Wine.—(1) White cotton or linen, fumes of burning sulphur, warm chlorine water. Coloured cottons or woollens, wash with tepid soapsuds or ammonia. Silks the same, with very gentle rubbing. (2) First rub the spot on each side with hard soap, and then lay on a thick mixture of starch and cold water. Rub this mixture of starch well into the spot, and afterwards expose it to the sun and air. If the stain has not disappeared at the end of 3 or 4 days, repeat the process. (3) Stains of wine may be quickly and easily removed from linen, by dipping the parts which are stained into boiling milk. The milk to be kept boiling until the stain disappears.

Grease and Oil.—(1) For white linen or cotton goods, use soap or weak lye. For coloured calicoes, warm soapsuds. For woollens, soapsuds or ammonia. For silks, benzine, ether, ammonia, magnesia, chalk, yolk of egg, with water. (2) Dissolve 1 oz. pearlash in 1 pint water, and to this solution add a lemon cut into thin slices Mix well, and keep the mixture in a warm state for 2 days, then strain and bottle the clear liquid for use. A small quantity of this mixture poured on stains, occasioned by either grease, oil, or pitch, will speedily remove them. Afterwards wash in clear water. (3) Carbonate of magnesia—magnesia that has been previously calcined is best—is dried in an oven and mixed with sufficient benzine to form a soft friable mass. In this state it is put into a wide-mouthed glass bottle, well-stoppered and kept for use. It is spread pretty thickly over the stains, and rubbed well to and fro with the tip of the finger. The small rolls of earthy matter so formed are brushed off, and more magnesia is laid on and left until the benzine has evaporated entirely. Materials that will bear washing are then cleaned with water ; on silks, alcohol or benzine should be used instead. The process may be applied to textile fabrics of every description, except those containing very much wool, to which the magnesia adheres very tenaciously. It may also be used for stains, old or new, on all sorts of fancy woods, ivory, parchment, etc., without risk of injury. Ordinary writing ink is not affected by it, but letterpress quickly dissolves, owing to the absorption of the fatty matter in the ink. (4) A method of cleansing greasy woollen or cotton rags and waste. The rags are thrown into a closed revolving drum, with a quantity of perfectly dry and finely-powdered plaster-of-Paris; when the plaster has absorbed all the grease, the whole is transferred to another revolving drum, pierced with holes, by which means the greater portion of the greasy plaster is got rid of. The operation is finished by beating the rags on a kind of wooden sieve. (5) In the removal of grease from clothing, with benzol or turpentine, people generally make the mistake of wetting the cloth with the turpentine and then rubbing it with a sponge or piece of cloth. In this way the fat is dissolved, but is spread over a greater space and is not removed; the benzol or turpentine evaporates, and the fat covers a greater surface than before. The way is to place soft blotting-paper beneath and on top, of the grease spot, which is to be first thoroughly saturated with the benzol, and then well pressed. The fat is then dissolved and absorbed by the paper, and entirely removed from the clothing. (6) Castile soap in shavings, 4 oz.; carbonate of soda, 2 oz.; borax, 1 oz.; aqua ammonia, 7 oz.; alcohol, 3 oz.; sulphuric ether, 2 oz. Soft water enough to make 1 gal. Boil the soap in the water until it is dissolved, and then add the other ingredients. Although it is not apparent what good 2 oz. of ether can do in a gallon of liquid, the mixture is said to be very efficient. (7) Make a weak solution of ammonia by mixing the ordinary "liquor ammoniæ" of the druggist with its own volume of cold water, and rub it well into the greasy parts, rinsing the cloth in cold water from time to time until the grease is removed. The ammonia forms a soap with the fatty acids of the grease, which is soluble in water.

(8) *On paper.*—Press powdered fullers' earth lightly upon the greasy spot, and allow it to soak out the grease. (9) Hannett says the spots may be removed by washing the part with ether, chloroform, or benzine, and placing between white blotting-paper, then passing a hot iron over. (10) A more expeditions, and thought by some, the best way, is to scrape fine pipeclay, magnesia, or French chalk on both sides of the stain, and apply a hot iron above, taking great care that it is not too hot. (11) After gently warming the paper, take out all the grease you can with blotting-paper, and a hot iron, then dip a brush into essential oil of turpentine, heated almost to ebullition, and draw it gently over both sides of the paper, which must be kept warm. Repeat the operation until all is removed, or as often as the thickness of the paper may render necessary. When all the grease is removed, to restore the paper to its former whiteness, dip another brush in ether, chloroform, or benzine, and apply over the stain, especially the edges of it. This will not affect printers' or common writing ink. (12) Lay on a coat of indiarubber solution over the spot, and leave it to dry. Afterwards remove with a piece of ordinary indiarubber. Any operation with ether, chloroform, or benzine, should never be conducted by candle-light, as their vapour is apt to kindle even at several feet from the liquid. No. (10) will remove grease from coloured calf, even if the spot be on the under side of the leather, it may thus be clearly drawn right through. (13) Apply a solution of pearlash (in the proportion of 1 oz. pearlash to 1 pint water) to oil-stained drawing-paper.

(14) *Calico.*—Immerse the stained calico in strong soda and water, and then well wash in clean water. The soda would saponify the oil, and so render it soluble in water. If you want to carry on the cleaning process on a large scale, the best way is to boil the goods in lime water or a solution of any alkali, and then well wash them. (15) To get grease out of woollen goods, the best way to proceed is to immerse them in a cold bath,

consisting of stale urine and water, for about 20 minutes. During this time the carbonate of ammonia evolved in the decomposition of the urea combines with the grease, forming a substance which is readily removed by washing. (16) Work your linen in a lye of soda; say 1 gill commercial caustic soda to every 2 gal. water; boil, and steep in this 1 hour; wash and steep 2 hours in a solution of bleaching liquor; 1 gill bleaching liquor, at 28° Tw., to every gallon of water; wash from this, and steep 1 hour in a weak sour, say 1 gill spirits of salts to 1 gal. liquor; now wash repeatedly in water, when the stains will disappear, and the linen become clean and white.

(17) *Felt Hats.*—Wash in a hot solution of soda or sesquicarbonate of ammonia.

(18) *Floors.*—Take ¼ lb. fullers' earth and ¼ lb. pearlash, and boil together in 1 qt. water, and, while hot, spread it on the greased surface, allowing it to remain 14 or 15 hours; after which it may be scoured off with sand and water. (19) Procure some good light benzoline, scrub the stained portion with a hard brush dipped in this, then wipe with a dry flannel. Make a strong solution of common washing soda in hot water, place a little unslaked lime, broken into coarse powder, over the stains, and pour on sufficient solution of soda to wet the lime thoroughly. Leave this mixture on for a short time, then scrub hard with plenty of clean hot water, and wipe dry with clean flannel.

(20) *Carpet.*—Upon the grease stain lay a little damp fullers' earth, and, after standing for some time, rub it gently into the carpet, and then wash off by using a little carbonate of ammonia, and the colour will be restored.

Ink and Ironmould.—(1) Equal parts of cream of tartar and citric acid, powdered fine, and mixed together. This forms the salts of lemon as sold by druggists. Directions for using: Procure a hot dinner-plate, lay the part stained in the plate, and moisten with hot water; next rub in the above powder with the bowl of a spoon until stains disappear; then rinse in clean water and dry. (2) Place the stained part flat in a plate or dish, and sprinkle crystals of oxalic acid upon it, adding a little water; the stains will soon disappear, when the linen should be well wrung out in two or three changes of clean water. (3) Dip the part in boiling water, and rub it with crystals of oxalic acid; then soak in a weak solution of chloride of lime—say 1 oz. to the quart of water. Under any circumstances, as soon as the stain is removed, the linen should be thoroughly rinsed in several waters. (4) The 'Journal de Pharmacie d'Anvers' recommends pyrophosphate of soda for the removal of ink stains. This salt does not injure vegetable fibre, and yields colourless compounds with the ferric oxide of the ink. It is best to first apply tallow to the ink spot, then wash in a solution of pyrophosphate until both tallow and ink have disappeared. (5) Thick blotting-paper is soaked in a concentrated solution of oxalic acid and dried. Laid immediately on a blot, it takes it out without leaving a trace behind. (6) Muriate of tin, 2 parts; water, 4 parts. To be applied with a soft brush, after which the paper must be passed through cold water. (7) Hydrochloric acid and hot water, in the proportion of 8 of hot water to 1 of acid; if not strong enough, add more acid; when clear of stain, wash well and boil, to remove all traces of acid. (8) A weak solution of chloride of zinc.

(9) *On Furniture.*—Put a few drops of spirits of nitre (nitric acid) in a teaspoonful of water, touch the spot with a feather dipped in the mixture, and, on the ink disappearing, rub immediately with a rag wetted in cold water, or it will leave a white mark. It should then be polished with furniture paste. (10) Undiluted spirits of salts (hydrochloric acid) may be used in the same manner, with care.

(11) *Printers' Ink.*—Put the stained parts of the fabric into a quantity of benzine, then use a fine, rather stiff brush, with fresh benzine. Dry and rub bright with warm water and curd soap. The benzine will not injure the fabric or dye.

(12) *Marking Ink.*—Dissolve 1 oz. cyanide of potassium in 4 oz. water; this mixture is very poisonous, and should, therefore, be used with great caution. Moisten the stained part of the garment with this solution by dipping it into it, or by means of a small brush; and in a few hours the stain will be obliterated. (13) To a solution of strong cyanide of potassium add a few grains of iodine. Repeated applications will remove any stain caused by nitrate of silver. (14) Grimm proposes the following method: Chloride of copper is first applied to the tissue; it is next washed with hyposulphite of soda solution, and afterwards with water. It is said that this may be employed on coloured woven cotton tissues. For white cottons and linens, dilute solutions of permanganate of potash and hydrochloric acid, followed by the hyposulphite of soda and clear water, are preferable. For cleaning the hands, iodine dissolved either with iodide of potassium, or in alcohol, is used, followed by aqua ammonia.

(15) *Indian Ink.*—To remove a blot, dip a camel-hair brush in water, and rub over the blot, letting the water remain on a few seconds; then make as dry as you can with blotting-paper, then rub carefully with indiarubber. Repeat the operation if not all removed. For lines, circles, etc., dip the ink-leg of your instruments in water, open the pen rather wider than the line, and trace over, using blotting-paper and indiarubber, as for a blot. Applicable to drawing-paper, tracing-paper, and tracing-linen. If the surface is a little rough after, polish with your nail.

Iodine.—Stains of iodine are removed by rectified spirit.

Lime, Lye, Alkalies.—White cottons and linens, wash with cold water. Coloured goods and silks, a weak solution of citric acid applied with the tip of the finger to the spot previously moistened with water.

Mildew.—(1) Well mix together a spoonful of table salt, 2 of soft soap, 2 of powdered starch, and the juice of a lemon. Lay this mixture on both sides of the stain with a painter's brush, and then lay the article on the grass, day and night, until the stain disappears. (2) Get a piece of flannel, dip it into whisky, and well rub the place marked; then iron on the wrong side, taking care to put a piece of damp cotton cloth between the iron and silk, and iron on the cotton cloth, which will prevent the silk assuming a shiny, glazed appearance. (3) Wash clean, and take every particle of soap off, then put the linen into a galvanised bath or tub full of clean cold water, procure a little chloride of lime, and tie it up in a muslin bag or piece of muslin, dissolve the lime in lukewarm water by squeezing the bag, then pour the water among the clothes. Stir and leave them for 24 hours, but do not put too much lime, or you will rot the clothes; then well rinse in clean cold water.

Milk and Coffee.—These stains are very difficult to remove, especially from light-coloured and finely-finished goods. From woollen and mixed fabrics, they are taken out by moistening them with a mixture of 1 part glycerine, 9 water, and ½ part aqua ammonia. This mixture is applied to the goods by means of a brush, and allowed to remain for 12 hours (occasionally renewing the moistening). After this time, the stained pieces are pressed between cloth and then rubbed with a clean rag. Drying, and, if possible, a little steaming, are generally sufficient to thoroughly remove the stains. Stains on silk garments which are dyed with delicate colours, or finely finished, are more difficult to remove. In this case 5 parts glycerine are mixed with 5 parts water, and ½ part of ammonia added. Before using this mixture, it should be tried on some part of the garments where it cannot be noticed, in order to see if the mixture will change colour. If such is the case no ammonia should be added. If, on the contrary, no change takes place, or if, after drying, the original colour is restored, the above mixture is applied with a soft brush, allowing it to remain on the stains for 6 or 8 hours, and is then rubbed with a clean cloth. The remaining dry substance is then carefully taken off by means of a knife. The injured places are now brushed over with clean water, pressed between cloths, and dried. If the stain is not then removed, a rubbing with dried bread will easily take it off. To restore the finish, a thin solution of gum arabic, or in many cases beer is preferred, is brushed on, then dried and carefully ironed. By careful manipulation these stains will be successfully removed.

Paint, Varnish and Resin.—(1) For white or coloured cotton and woollen goods, oil of turpentine or benzine, followed by soapsuds. For silk, benzine, ether, soap; hard rubbing is to be avoided. For all kinds of fabrics chloroform is best, but must be carefully used. (2) Stains of paint or varnish, after being softened with olive-oil or fresh butter, may generally be removed by the same means as ordinary grease spots. (3) Saturate the spots with a solution of equal parts turpentine and spirits of ammonia; wash out with strong soapsuds.

Stearin, Sperm Candles.—For all kinds use 95 per cent. alcohol.

Tannin, Walnut Shells.—White cottons and linens, Javelle water (liquor sodæ chlorinatæ), warm chlorine water, concentrated solution of tartaric acid. Coloured goods or silks, chlorine water, diluted according to the tissue and colour, each application to be followed by washing with water.

Tar, Axle Grease.—White cottons and linens, soap, oil of turpentine, and water, each applied in turns. Coloured cottons and woollens, first, smear with lard, rub with soap and water, and let it stand for a short time; then wash with oil of turpentine and water, alternately. Silk the same, using benzine instead of turpentine, and dropping the water from a certain height on the under side of satin. Avoid rubbing.

Stills.—Carles recommends the use of carbonate of ammonia as an effective means of cleansing the worms of stills. The carbonate of ammonia is mixed with water in the still, and, being slowly carried over in the gaseous condition with the vapour of water during distillation, it penetrates to every part of the apparatus attacking resins, fatty bodies, sulphuretted products, etc., and after about an hour only a perfectly inodorous limpid water flows from the worm.

Stones.—To remove grease from stone steps or passages, pour strong soda and water boiling hot over the spot, lay on it a little fullers' earth made into a thin paste with boiling water, let it remain all night, and if the grease be not removed, repeat the process. Grease may sometimes be taken out by rubbing the spot with a hard stone—not hearthstone—using sand and very hot water, with soap and soda.

Stuffed Animals (*and see* FURS). (1) Give the animal a good brushing with a stiff clothes-brush. After this warm a quantity of new bran in a pan, taking care it does not burn, to prevent which, quickly stir it. When warm, rub it well into the fur with your hand. Repeat this a few times, then rid the fur of the bran, and give it another sharp brushing until free from dust. (2) Sponge with white soap and warm water, rubbing well into and about the roots of the hair, but avoid using an excess of water to soak into the stuffing, or the specimen will, in all probability, never thoroughly dry, and moths and rot will be the result. Dry in a current of air as free from dust as possible; brush the fur occasionally as it dries (a coarse comb at first will, perhaps, separate the hairs better). Before putting it into its case, wash freely with benzoline, rubbing with the fur; you may never dread moths, and your specimen will always be clean, if your case is properly made and closed up air-tight by means of paper pasted over every joint and crack.

Tar-Spots, to remove.—Butter will remove tar-spots. Soap and water will afterwards take out the grease-stain.

Teapot.—(1) Fill with boiling water and add some strong washing soda; let it remain for a day or two. (2) Weak solution of spirits of salt (hydrochloric acid).

Textile Fabrics.—Cleaning and scouring are, with dyers, divided into "English" and "French." The reason of these two names does not appear, as one method is as much practised by each of the two nations as the other. That known as the English method consists in scouring and washing the article to be cleaned, with a strong solution of soap, or soap and pearlash, and afterwards well rinsing it in pure water. This is the only thorough method of cleaning, and should always be adopted when the fabric is much soiled and dirty. For cleaning carpets and hearth-rugs, the English method is divided into thorough cleaning and dry cleaning. The difference between these two consists more in the manner of carrying out the several operations than in the processes themselves. In dry cleaning, when once the operation has been commenced it must be continued until the fabric—carpet or rug—is as dry as it can be got by rubbing with dry cloths; and care must also be taken that the liquor does not soak through and wet the back. In thorough cleaning, the carpet is saturated with the soap liquor. French cleaning is done with camphine, and is especially applicable for silks or satins which are not much soiled; as, if used with care and despatch, it will not injure the most delicate colours.

Cleaning with Benzine.—Scouring with benzine has proved to be one of the best methods, since the end is accomplished without shrinkage or injurious effect upon the colour or finish, so that the garments need not be taken apart, nor lace or velvet trimmings be taken off, while with men's clothing it is not noticeable that they have been washed. The articles, freed from dust and dirt by beating them while dry, are thoroughly moistened with benzine in a tinned-copper or stoneware vessel, and well squeezed in it with the hands; silk pieces, ribbons, and heavier portions that may require it being brushed well on a zinc-covered table supplied with a tube beneath for re-collecting the benzine. The deepest stains are marked and treated more thoroughly. The articles are similarly treated in a second bath of benzine, and then carefully dried in a centrifugal machine for 10 to 15 minutes, the benzine being re-collected in a vessel beneath. On removal from it they are smoothed out and hung in a warm drying-room, with access of air. It will require 10 to 12 hours after they are dry to remove the odour completely. Since benzine acts principally upon fatty matter, stains of street mud, meal, etc., may remain, and must be removed by gently rubbing with a soft sponge dipped in cold water to which a little alcohol has been added, and then drying with a soft silk cloth. Sugar, champagne, and egg stains are also removed with cold water, and the colour is brought up again with a little acetic acid and alcohol in water, the spots being well rubbed out. Blood spots are treated similarly. In all these cases the formation of marginal stains around the spots must be prevented by thorough use of the soft sponge and soft silk cloth. An article that still retains decided stains is brushed with a cold decoction of soap-bark, to which some alcohol has been added, and is then rapidly passed through water, and then through water slightly acidulated with acetic acid, and dried rapidly. Kid gloves are well rubbed with the hands, separately, in benzine, and each finger well rubbed on a stretcher with a rag, and after being blown out are hung up to dry. Articles treated with benzine need but little subsequent finishing, and this may be accomplished by applying a solution of gum arabic in water, and a little alcohol, uniformly with a rag, and ironing. Portions of coats that have been taken apart need simply to be stretched and moistened uniformly with alcohol, and allowed to dry rapidly. Heavy cloth, velvets, etc., after being well steamed, are treated on the wrong side with so little dressing (best of tragacanth) that it does not go through, and are then placed on the finishing frame or warm drum. White furs and angora tassels are passed immediately from the benzine through pulverised chalk, and allowed to dry, and are then beaten out, when the leather will remain elastic and the fur look well. Benzine that has become turbid by use may be purified by stirring 10 drops of oil of vitriol thoroughly into about 2 bucketfuls of it, and allowing it to settle. *The operation must, of course, not be conducted near the lamp or fire, on account of the combustibility of benzine.*

Apparatus.—Board required for cleaning with Camphine.—The scouring board for French cleaning ought to be 6 ft. long and 3 ft. wide, and should be made of 1-in. American pine, free from splits and knots, and planed very smooth and level. One side of this board is covered with green or drab baize, stretched very tight and smooth, and fastened to the edges by tinned-tacks. Besides this board will be required 3 silk-scouring brushes, of different degrees of hardness—these should be bought of a dyers' brush-maker; a large sponge, some clean pieces of flannel, and some clean India-cotton cloths and sheets.

Camphine is a variety of spirits of turpentine, and is obtained from the *Pinus australis* of the Southern States of America. It is sold in sealed tin boxes or cans, containing 1 qt., 2 qt., or 1 gal. each, and can be obtained at almost any oil shop or drysalter's. When it is too dirty for further use, it is taken back to the shop at which it was purchased and exchanged for clean; one pint of clean camphine being given for each quart of that which is dirty.

Common Sour is prepared by stirring into clean water sufficient oil of vitriol to make it taste sharp. The vitriol is to be bought at a drysalter's, not at a chemist's.

Drying.—Dresses, and all coloured fabrics, should always be dried in the shade, and never in the sunshine; for the best colours are sure to fade, if they are exposed to the glare of the sun, and more especially will they do so when wet.

Frame for finishing Silks, etc.—This consists of a frame, made generally of oak and iron, on which the silks are stretched before sizing; and is so constructed that a pan containing burning charcoal may be run backwards and forwards under the silk to dry it.

French Board, for finishing Silks, etc.—Have a deal board, about 4 ft. 6 in. long, 2 ft. wide, and 1 in. thick. Cover this board loosely with fine green or drab baize, well tacked to the edges of the board, and then stuff it with wool from both sides, until it is very tight and smooth. When stuffed, it should be slightly raised along the centre of its length and slope off towards each side. To use this board, take a width of the silk or satin which has been cleaned, lay it flat and smooth on the baize, and then sponge it carefully all over with a mixture of size and water. When this has been done, pin down first one end and then the other, and also the two sides. The silk is to be well stretched while being pinned, and the pins are to be put in about 1 in. apart. Rub the face of the silk once more with a damp sponge, and then dry it before a clear fire. When dry, unpin and take it off the board, and it is finished.

Hot Stove.—A hot-stove room is the best place in which to dry work which has been cleaned with camphine; and the hotter the room is the sooner will the smell of the camphine be expelled from the fabrics.

Irons.—The best kind of iron to use for ironing dresses, ribbons, etc., is a box iron, on account of its cleanliness.

Pegs are pieces of wood, firmly fastened into the walls of the dye-house, at a height of 6 ft. from the floor, and projecting from the wall about 18 in., and are placed at intervals of about 2 ft. Articles which have been cleaned or dyed are put on these pegs to drain. When cleaning curtains, dresses, or other similar articles, the kettle or tub is always stood under one of these pegs. For domestic use, a plain deal horse, made like a towel-horse, may be substituted for these pegs.

Puncher.—This instrument is used for beating or punching those articles which are too heavy to be taken in the hands and rubbed. It consists of a rather heavy mallet-like block of hard wood, fixed to a long tapering handle.

Size for Coloured Bonnets. — Break up 1 lb, of the best glue, put it into a vessel with 4 qt. of cold water, and let it soak for not less than 12 hours. Then pour it, water and all, into a saucepan, and put it over the fire to dissolve. Keep it well stirred, and be careful not to let it boil. When it is all well melted, strain it into an earthenware pan, and use it while it is scalding hot. The bonnets as they are taken out of this size must be sponged as dry as possible, and the shape regulated, and then hung up to dry. This quantity is sufficient for 12 bonnets.

Soap.—The best kind of soap to use is Feild's oil soap. This kind has no unpleasant smell, and does not congeal after being dissolved. Mottled soap is the next best kind, but it requires to be used while warm to get it well into the work. The great drawback to its use is, that after being dissolved, if it is allowed to cool it congeals, and therefore it is not suitable for cold scouring and cleaning. Soft-soap, which is made from fish-oil, is not fit for general use, on account of the fishy smell remaining in the work.

Starch.— Mix a quartern of the best flour with cold water, and when it is well mixed pour on it two pails of scalding water, and put into it 2 oz. of beeswax. Now set it to swim in a copper of boiling water for ½ hour, and stir it occasionally. Take it out of the copper and strain it into a clean vessel, and when cool it is ready for use. This is for starching articles which are to be friction-calendered or glazed. The best starch for dresses, and for all domestic uses, is the Glenfield starch.

To Handle is to pass the work from one hand to the other, by the selvage, keeping it under the liquor all the time.

To Sheet-up.—To rub dry with sheets.

Water.—All water used for cleaning or scouring, whether hot or cold, should be quite pure and clean.

Ancient Tapestry.—Dissolve a bar of soap in 1 gal. boiling water; when cold put 1 qt. of this dissolved soap into 1 gal. cold water. Have ready at hand some pieces of soft flannel, a soft brush, a piece of washleather, and some clean, dry sheets. First well brush with a hard, long-haired clothes-brush, taking care to remove all the dust from the corners; for this latter purpose it is better to use a small pointed brush and a pair of bellows. If the tapestry is on the wall, begin to clean it at the top, but do not clean more than 1 sq. yd. at a time. Dip a piece of flannel into the soap liquor, squeeze it out gently, and well rub it into the tapestry to make it lather, and well brush with a soft brush. Then wring the flannel out of the soap liquor, and dry the square with the soapy flannel and the washleather, and afterwards dry with the sheets. The tapestry is to be dried with the soap in it, for on no account must it be rinsed. Dissolve 4 oz. tartaric acid in a pint of boiling water, and put it into a pan containing 2 gal. cold water. Dip a clean sponge into this acid water, squeeze it, and then well rub it into the spot you have just cleaned and dried. When this has been done, it must be again well dried with the sheets before being left. And so proceed, 1 sq. yd. at a time, until the whole is cleaned. The soap liquor must be thrown away, and a fresh lot mixed as often as it becomes dirty. When the tapestry has all been cleaned, and it is quite dry, take a lump of pipeclay and well rub it into it, and then brush it with a clean clothes-brush. This last process takes out the soap and spirits, and also brightens the colours. Keep a good fire in the room while you are cleaning the tapestry.

Carpets.—All carpets and hearthrugs, whether intended for dry or thorough cleaning, must first be well beaten, and swept or brushed with a hard broom. A carpet, to be properly beaten, should be hung on a stout line, the wrong side outwards, and well beaten by two or more persons, according to its size, some standing on one side and some on the other. The sticks used should be pliable, and well covered at the ends with cloth in the form of a knot in order to prevent the carpet being torn or the seams split by the sharp ends of the sticks. After being thoroughly beaten on the wrong side, the carpet should be turned and treated in the same manner on the right side.

Dry Cleaning.—Have ready a number of dry coarse cotton or linen cloths, some coarse flannels, and one or more large pieces of coarse sponge; two or more hard scrubbing or scouring brushes, some large tubs or pans, and pails, and also a plentiful supply of both hot and cold water.

First take out all grease spots; this may be effected in several ways. Well rub the spot with a piece of hard soap, and wash out with a brush and cold water, and well dry each spot before leaving it.

Or use, instead of the soap, a mixture of fullers' earth, gall, and water, well rinsing and drying each spot as before. When this has been done, the carpet may be cleaned by one of the three following methods:—

(1) To Dry Clean with Soap Liquor. —Cut up a bar of soap and dissolve it over a fire in 2 gal. water. Put 2 qt. of this dissolved soap into a pail of warm water. Dip a scrubbing brush into this soap liquor, and scour with it about 1 sq. yd. of the carpet; be careful not to let the liquor soak through to the back. When this piece is thoroughly cleaned, rub the soap well out of it by means of a coarse flannel or sponge, sucking up all the wet and dirt made by the brush; rinse the flannel or sponge frequently in warm water. Now take a clean sponge and dip it into a pail of common sour, squeeze it out, and then rub the sour well into the part just cleaned and rinsed. Rub as dry as possible with clean coarse cotton or linen cloths before proceeding with the cleaning. The whole carpet is to be cleaned, spirited, and dried in the same manner, a square yard at a time.

(2) To Clean with Gall.—Put a bag of very fresh bullocks' gall into a pail containing 2 gal. cold water, with 4 oz. pearlash dissolved in it, and well mix it either with a stick or your hands. Have ready, besides this, 2 pails cold water, a large sponge, a couple of flannels, and some dry coarse cloths. Dip the brush into the gall and water, and scrub the carpet, a square yard at a time, as quickly and as carefully as possible. Rinse, and suck up the gall and dirt with a large flannel or sponge, which is to be frequently rinsed in the pails of cold water. Well dry with cloths before beginning a second square.

By adopting this simple process, any carpet, whatever its size, may easily be cleaned on the floor; the process is especially useful when the carpet is not very dirty, or when it contains delicate colours, as the gall cannot possibly injure them. The only objection to this method is that when cleaned with gall there is often a disagreeable smell left in the carpet; but if the gall be obtained from a fresh killed bullock, and the carpet, after cleaning, be hung for a few hours in a current of fresh air, the whole of this smell will go off.

(3) To Clean with Ammonia.—Dissolve in a small pan 4 oz. pearlash in hot water, and mix with it 1 gal. ammonia, which must be obtained from a drysalter, not from a chemist. Dip a sponge or coarse flannel into the ammonia, take it out rather wet, and well rub it into the carpet, then dip the scouring brush into the liquor and well scour the part already sponged as quickly as possible. The dirt and ammonia must then be sucked up in the sponge or flannel, and the part well dried with flannels and cloths before proceeding with the next. Each square yard will take about 20 minutes to clean and dry thoroughly.

This is another very simple method, the only objection to it being that the carpet will smell of the ammonia for some time if it is kept in the room in which it has been cleaned; it should therefore be hung for 3 or 4 days in the open air or under an open shed, taking care, however, that it does not get wet.

In dry cleaning, special care must be taken not to allow the liquor to soak to the back of the carpet or rug; and also that, before commencing, the floor or board on which the operation is conducted, is perfectly dry. A good fire should also be kept in the room during the whole time, as much of the success of the operation depends on rapid drying.

Thorough cleaning. (*a*) Lay the carpet on a stone floor, having a fall of about 6 in., so that the soap and water may drain off as used, and well scour with a long-handled scouring brush, using the dissolved soap liquor in the manner described in the first process for dry cleaning. When well scoured all over, scour out the soap and dirt with plenty of cold water, fold and lift on to pegs to drain. While the carpet is draining, sweep and well rinse the flags; and then lay down the carpet, and well rinse and scour it a second time with plenty of cold water. Refold and hang on the pegs to drain, and again well rinse and sweep the flags. This must be repeated until all the soap and dirt have been got out of the carpet; it must then be hung on the pegs, and the floor once more swept and rinsed. Have a tub or other vessel containing 12 pails cold water, and stir into it ¼ pint oil of vitriol; spread the carpet evenly on the floor, and, with a pail, pour this sour carefully all over the carpet, and well work it in with a carpet broom. This, which is a very important process in carpet cleaning, must be performed with care and attention to the colours, especially when there are greens and blues. When done, fold up the carpet very smoothly and put it on the pegs to drain, and afterwards dry as quickly as possible, either in a hot room or, on a dry day, in the open air.

(*b*) Have a board 3 ft. wide and 12 ft. long, so that two persons can work at it at the same time. Place this board on trestles, or horses, 3 ft. high, and on the ground underneath it place other boards, on which to drop the carpet as the scouring progresses. Place the carpet smoothly on the scouring board, face upwards, and well scour with hand-scouring brushes, using the soap liquor as before. When this length has been scoured, pull the carpet towards you, and let it drop smoothly on to the boards at your feet, and then scour the second width in the same manner; and so proceed until the whole carpet has been scoured. Then fold it up and put it on the pegs to drain, and clean away all the soap and dirt from the boards and floor. Place the carpet on the scouring board as at first, and well scour out the soap and dirt with plenty of cold water; fold up the carpet and put it on the pegs to drain, and again rinse the boards and floor; and so continue until all the dirt and soap have been got out of the carpet. Then well clean the scouring board, the boards at your feet, and all places about them. Put the carpet once more on the scouring board and finish with the sour as directed for the first method, well scouring it in breadth by breadth. Drain and dry as before. Carpets cleaned in this manner will look and wear as well as when they were new.

(c) First take out all the grease spots with a mixture of fullers' earth and gall. Dissolve 1 lb. pearlash in boiling water, put it into a tub with 6 pails of cold water, and then well mix into it 2 large gall bags, which should be very fresh; this will be sufficient to clean a carpet containing about 30 sq. yd. Spread the carpet either on the flags or on the scouring board, and use this preparation in exactly the same manner as you would the dissolved soap liquor; scouring, rinsing, spiriting, and drying the carpet just the same.

Never attempt to clean the back of any carpet, as the backs are sure to get clean with cleaning the face.

Cloth.—Cloth trimmings often become soiled, and unless cleaned, the appearance is impaired. Benzine and naphtha are used with success for this purpose upon grease spots, but when there is no grease, the materials fail, and are likely to produce bad results, owing to the oil that is contained in them. To remove the oil place a quantity of benzine in a bottle and drop into it a little oxalic acid; this will carry with it to the bottom of the glass all the oil remaining in the benzine, leaving the greater part perfectly pure. After standing for an hour or two, carefully pour off the clear fluid on the top into another bottle, and it will be ready for use.

Curtains, Bed Furniture, etc.—Chintz.—Printed or chintz curtains do not require to be unpicked or unlined for cleaning and glazing; but if they are to be friction-calendered, they must be unlined and taken apart in breadths. Lined furnitures, as sofa, chair, or ottoman covers, and hangings which have not been unpicked, must have a strong and good starch, which will require to be well worked into them. Unlined furnitures and linings, which are to be friction-calendered, will only require to be carefully passed through a thin starch; if, however, they are to be glazed, they will require the strong starch the same as the lined furniture. If dried before being starched, all kinds of furniture will take one-fourth less starch, and will also be much stiffer than if starched while wet. Furniture which is to be friction-calendered must, after starching, be wrung across the width, and the ends and edges well shaken out and pulled straight; and they should afterwards be hung up very straight by the ends.

To clean the furniture: Dissolve a bar of soap in 4 gal. boiling water. Put 1½ gal. of this soap liquor into a vessel containing 4 pails of cold water. This is called the first liquor. Into another vessel put the same proportions of cold water and dissolved soap, for the second liquor; and put the remaining gallon of soap liquor into a third vessel containing 4 pails of cold water. This is the thin soap liquor. Put your furniture into the first soap liquor, and well rub and punch it; wring it out and put it into the second liquor, and well rub, punch, and turn it in this; then wring it out again and pass it into the third or thin liquor to finish, and give it a clean water directly after. Now well rinse it through 3 lots of moderately warm water to take out all the soap; and afterwards starch by well working the starch all through it. When this has been done, well shake it and fold it neatly; when dry, send it to the calico glazers to be finished.

When the furniture is to be friction-calendered, first well punch the print in a tub of clean water, and while the print is draining, well punch the lining in the same water, and repeat this with a second tub of water. The furniture is then to be cleaned, rinsed, and starched, as above directed; excepting that the print is to be passed first through each soap liquor and rinsing water, and through the starch and the lining is to follow in the same order.

Damasks.—Dissolve 6 lb. soap in 8 gal. boiling water; and in another vessel dissolve 3 lb. best pearlash in 2 gal. boiling water. First clean the curtains, one at a time, in two lots of clean water, well working them in each water; then fold them up smoothly, and put each curtain on a peg by itself to drain. Put 6 pails warm water into a tub, and into this put 2 qt. of the pearlash liquor and 2 gal. of the soap liquor. Put one of the curtains into this liquor, and well work it with the puncher for 10 minutes, then fold it up and put it on a peg to drain, and treat the other curtain exactly in the same manner. Now throw this liquor away, and make up a second lot with the same proportions as the first. Pass the curtains through this in the same manner as before, letting the one which was second be first this time. Put this liquor into another vessel and make up a third lot, and well work the curtains in this as before. Empty this liquor into the vessel containing the last, and mix another lot. Punch the curtains in this as before, one at a time, for 10 minutes, fold up and put on the pegs to drain, and they are ready for spiriting. Rinse your tub and put into it 12 pails of cold water, and into this stir ½ pint of oil of vitriol. Open your first curtain and well handle it in this spirit water for 10 minutes, then fold and hang up to drain. Stir another ¼ pint of oil of vitriol into this same water, and treat the second curtain in the same manner as the first. Now throw this spirit water away, well rinse the tub, and fill it with cold water. Rinse the first curtain in this, then throw away the water, refill the tub, and rinse the second curtain. Fold them up smoothly, drain them, and they are ready for drying. To dry these curtains properly they must be hung up in a warm room by the ends, the middle hanging down. This is of great importance and must be attended to, for if they are not dried straight, they cannot be re-made straight, and consequently will not hang again like new. After drying they are to be well shaken and picked out, and then sent to the pressers to be finished.

The proportions and quantities here given are for a pair of curtains, each containing 20 sq. yd.

Worsted-and-Cotton Damasks are to be cleaned exactly in the manner described above, excepting that after being spirited and rinsed, and before being pressed, they must have a water starch to make them look strong and well when finished.

Silk Damasks.—Dissolve 2 lb. Feild's soft-soap in 2 gal. boiling water, and while it is getting cold get ready your silk-scouring brushes and scouring board. Have 3 vessels, each containing 6 pails of cold water for rinsing, and a fourth, containing the same quantity of water, into which sufficient oil of vitriol has been stirred to make it taste sour; also a kettle, containing 4 pails of water for a soap liquor. Put 1 qt. of the soft-soap liquor into a pail of cold water, dip one width of the damask into this, then put it on the scouring board, the wrong side up, pour some of the dissolved soap on it, and well brush with the silk-scouring brush. This must not occupy more than 5 minutes. Turn it and clean the right side quickly with the brush and more of the soft-soap. Now take it off the board and pass it through the first soap liquor, then through the thin liquor, the rinsing waters, and the spirit water; well handling it in the spirits for 2 minutes. Wring it, fold it up, and dry; and so proceed for each width, the quantities here given being sufficient to clean about 10 sq. yd. After drying, they must be damped, brushed, and framed, and sent to the pressers to be finished.

Silk Damasks may also be cleaned with camphine, in the following manner: Well shake and brush the curtains, and take the widths apart. Have ready the camphine board, brushes, and sheets. Put 1 gal. camphine into an earthenware pan that will hold 4 gal. Put in a width of the damask, and handle it in the camphine until it is well soaked, which will be in about 2 minutes; then fold it up and lay it on a peg over the pan so as to catch the liquor which drains from it. Now put it on the scouring board, wrong side up, and brush it well; then turn up the right side, and do the same with it. Pass it again through the camphine, fold it up, squeeze out of it as much of the camphine as possible, and lay it on the peg over the pan. Now turn your board the wood side upwards, and put your sheets on it. Then sheet-up the width which you have just cleaned, using one sheet after the other until it is quite dry; then brush it well on both sides, and hang it up to air and take off the smell of the camphine. Each width of the curtain or furniture is to be treated in exactly the same manner as above. When dry they are ready for dressing.

Mix 1 teacupful of parchment size with 4 qt. cold water. Frame the damask, and carefully wet all over with this by means of a clean sponge, and dry immediately with the charcoal fire. Afterwards send them to the pressers to be finished. Some dyers and cleaners prefer damping, brushing, and calendering as a finish for this work; while others frame or roll it only. But this will all depend on the quality of the work and the dressing.

Rapidity of operation is of great importance in this method, for if the operator be a dawdler the work is sure to suffer. Each width, from the time it is put into the camphine until it is hung up to air, should not on any account take more than 15 minutes.

Silk-and-Worsted, or French Damasks.—To clean a curtain, or other furniture containing about 10 sq. yd. Dissolve 3 lb. soap in 8 gal. boiling water; have ready 3 tubs, each containing 6 pails cold water, and into the first and second put 1 pail of the dissolved soap, and ½ pail into the third. Put into a large kettle, or other vessel, 6 pails cold water, and well stir into it ½ teacup of oil of vitriol.

Put the curtain into the first soap liquor, and well work it for 1 minute, then take it up by the selvage and wring it over the tub; put it back into the same liquor, and again well work it for a minute, and then well wring it on a peg over the tub. Now treat it in the same manner in the second liquor, then put it into the third or thin soap liquor, and when it has been well worked in this, handle it directly out of the soap into the spiriting, wring it out on a peg, put it back into the spirits, and again well handle it for about a minute, and then put it to drain. Throw away the first soap liquor, rinse the tub, and put into it 10 pails of cold water and ½ teacup of oil of vitriol. Well handle the curtain in this, wring it out, return it twice to the same liquor and then hang it on to the pegs to drain. Empty your tub and make up a second spirit water, with ½ teacup of oil of vitriol in 12 pails of water, well work the curtain in this, and afterwards put it to drain. After it has drained well, dry it with clean sheets, and then hang it in a warm room to finish drying. When dry, damp, brush, and send to the pressers to be finished. The sheeting-up should be carefully performed, and must on no account be omitted, as the whole safety of the colours depends on this operation. Each curtain is to be cleaned in the same manner, and will take about 6 sheets to properly dry it; but with each fresh curtain the second soap liquor is to be used as the first, and a fresh lot mixed for the second liquor.

Moreens are to be cleaned, rinsed, and spirited, exactly as first described for damasks. When sent to the pressers, moreens may be finished in one of the four following ways, plain, watered, embossed, or with satin and watered stripes, the charge per yard being about the same for each method.

Tabaret or Tabbarea.—This may be cleaned and finished in the same manner as described for silk damasks, excepting that when it is sent to the pressers it is to be watered instead of hot-pressed.

To clean with camphine: Have your

board, brushes, and drying cloths all ready, and put ½ gal. camphine into each of 2 earthenware pans that will hold about 2 gal. each. Well shake and brush the curtains, take out the linings, and take them apart. Put one width into one of the pans of camphine; when it is quite soaked, take it out and lay it on your board, wrong side up, and well brush it with the camphine; turn it and treat the right side in the same manner. Now pass it again through the first liquor, and then through the second, letting it drain on a peg over the latter for a minute. When it has drained sufficiently, sheet it up, dry with the cotton or linen cloths, then brush it with a dry brush, and hang it up to air and take off the smell of the camphine. Each width is to be cleaned in the same manner, using fresh camphine as often as necessary. When all have been dried, put them for a few minutes between some damp sheets, then take them out, brush, and rub them, and send to the pressers to be watered.

Satin.—Have 2 clean stoneware pans that will hold about 2 gal. each, and into each pan put 2 qt. of camphine. Shake and well brush the curtains and take them apart. Put one width of the satin into one of the pans of camphine, let it well soak through, and then drain it on a peg over the pan for about a minute. Now put it on the board, the wrong side up, and well brush it with a soft brush, occasionally wetting the brush in the camphine. When the wrong side has been cleaned all over, turn the right side up, and clean it with the brush in the same manner; and afterwards pass it through the first liquor, and then through the second, and well drain it. Now turn your board the plain side up, lay the width on it, and well dry with the cloths. After it is dry, brush it, first on the wrong side and then on the right side, with a dry brush, and then hang it up to air and take off the smell of the camphine. Each width is to be cleaned in the same manner, using clean camphine as often as required. Satins are generally finished in the frame in the manner described for silk damasks, and afterwards sent to the calender. Another very simple way is to slightly damp them between clean sheets, then brush them, and send to the pressers to be finished.

Satin and flowered velvet may be cleaned dry by mixing a quantity of fine dry breadcrumbs with a little powdered blue, and rubbing this on with a piece of soft material or flannel. Shake, and clean off with a clean, soft cloth or brush. White goods may be treated in this way.

Satins may also be cleaned, dried, damped, brushed, framed, and finished, exactly as described for silk damasks.

Tammy Lining.—(1) Dissolve 1 bar of soap in 4 gal. boiling water; have 3 vessels, each containing 2 gal. cold water. Into the first of these put 2 gal., into the second 1½ gal., and into the third 1 gal. of the dissolved soap. Tack the widths of lining together, end to end, and then put it into the first soap liquor, work it well in this, then put it into the second liquor, and again well work it. Now put it into the third liquor, handle it well in this, and afterwards put it on a clean peg to drain. Put 8 gal. cold water into a clean vessel, and stir into it one tablespoonful of oil of vitriol; handle the lining in this spirit water for 5 minutes, take it out, and rinse it in one lot of cold water for about a minute. Now dry it, and when dry have it re-glazed on the wrong side. (2) Mix together the crumb of a stale loaf and a quart of silver sand, and damp the mixture with camphine. Put a dry width of the tammy on the scouring board, and well work this mixture into it, on both sides. Then shake it and brush it, and it is cleaned. Again damp the mixture of bread and sand with a little fresh camphine, and clean the next width in the same manner. And so proceed for any number of widths. (3) Tammy lining may also be cleaned with camphine, in the manner directed for tabaret; but a flannel should be used to rub out the dirt instead of a brush.

When cleaned by either of these last two methods, the tammy will not often require re-glazing, unless it was very dirty before cleaning. But whenever it is necessary to re-glaze it, it should be done on the wrong side.

Bullion Fringe and Worsted Fringe should be cleaned in the soap liquors, spirited, rinsed, and dried, exactly as directed for tammy lining. But if the fringe contains any spickets, that is, pieces of wood covered with silk, these must be taken off and cleaned with bread-crumbs and camphine, or, if necessary, sent to the fringe makers to be re-covered.

Bullion Lace and Gimp are to be cleaned in camphine and dried in cloths, piece by piece, in the manner directed for tabarets.

Silk curtains, when soiled, may be made to look as good as new by washing them in a liquid composed of ½ pint gin, 4 oz. soft-soap, 2 oz. strained honey, well mixed; spread the silk out on a table and apply the mixture with a sponge, rubbing thoroughly; then wash in soft water, into which there should be put 2 tablespoonfuls of ox-gall to 3 gal. of water, rinse the silk, but do not wring it; hang it out smooth to dry, and iron when damp.

Dresses.—Silk.—Have two earthenware vessels that will hold about 2 gal. each, and put ½ gal. of camphine into each of them. Take the sleeves off the dress, and the body off the skirt. Clean the body first, next the sleeves, and the skirt last. Put the body to soak in the first liquor, and when it is well wetted, lay it on the board, and well brush it with the silk scouring brushes, first on the inside and afterwards on the outside. When this has been done, put it back into the first liquor, and then into the second, and let it drain on a peg over the latter for about a minute. Have a clean sheet spread out on the plain side of the board, take the body off the peg, and lay it smoothly on this, and well rub it, with clean India-cotton cloths, until quite dry. The sleeve and the skirt are to be cleaned and dried in exactly the same manner. Hang in a hot room to take off the smell of the camphine.

This is a very quick and easy way to clean a silk dress. But if it should be very dirty it will be found to be much better to take it apart into widths, and to clean each width separately by either of the two following methods: (1) Dissolve 2 lb. of soap in 2 gal. of boiling water, and use when cold. Have 4 pans, or other vessels, with 4 pails of cold water in each. Into one of these put a small quantity of the dissolved soap for a thin soap liquor, and in another dissolve ¼ lb. of tartaric acid for spiriting. The other two lots of water are for rinsing. Now begin and clean the dress as quickly as possible, for each width should not take more than 5 minutes from first to last, or it will probably be spoiled. Spread the width, wrong side upwards, on a clean scouring board which is rather longer and wider than a width of the dress. Pour over it sufficient of the dissolved soap to wet it thoroughly, and well brush it, lengthwise, with a soft brush; then turn it and treat the right side in the same way. When this has been done, pass it first through the thin soap liquor, then through the two rinsing waters, and afterwards well handle it in the spirit water, and then put it on a peg to drain. Now spread a clean, dry sheet on a dry board or table, lay on it the width which you have just cleaned, and well dry it with clean cloths, and afterwards brush it with a dry brush. When all the widths have been cleaned and dried they should be finished either in a silk-finishing frame or on a French board. Silks or satins should never be brushed across the widths, as doing so causes them to fray out, and spoils them for re-making.

(2) Have 2 clean earthenware pans, which will hold about 2 gal. each, and put ½ gal. of camphine into each. Take one breadth of the dress and dip it into the first lot of camphine, then spread it on the board, dip the brush into the camphine, and brush the

width as above directed. When this has been done, put it again into the first liquor, then into the second, and let it drain for a minute over the latter. Be sure to squeeze out as much of the camphine as possible before passing the width from one liquor to the other. Spread a clean sheet on the board, lay the breadth of silk on it, and dry thoroughly. And so proceed for any number of widths. Hang in a hot room to take off the smell of the camphine. Finish either in the frame or on the French board.

Satins may be cleaned by either of the methods given for cleaning silks, *also see Curtains.*

Irish Poplins and Tabinets are to be cleaned with camphine, in the manner directed for Tabaret curtains.

Lama.—Boil 1 lb. of the best rice in 1 gal. water for 3 hours, and when done pour off into a basin a sufficient quantity to starch the dress. When the remainder is partially cold, well wash the dress with it, without using any soap, and rinse in cold water. Wring it well, and starch it with the rice water put by for the purpose, and dry quickly before the fire. When sufficiently dry, it is ironed with a cool iron, as it is very liable to scorch ; use a wet cloth to damp the parts which may have become too dry for ironing. These dresses must on no account be allowed to lie damp, even for an hour, or they will be spoiled, as the colours are sure to run.

Alpacas, Printed Muslins, or Piqués may also be cleaned by this method, for if the operation be performed with care and dispatch, it will be found not to injure the most delicate colours.

Piqués and Coloured Muslins.—French method : Make a strong lather with best white soap dissolved in soft water, and use while rather warm, but not hot. Wash the dress in this, but do not soak it previously. As soon as the lather appears soiled, squeeze out the dress, throw away the lather, and wash the dress again in a second lot, and so continue until the dress is thoroughly clean. Then well rinse it in cold water, and afterwards in cold water slightly blued. Squeeze all the water out of the dress, but do not wring it, and hang in a shady place to dry ; or, if the weather be wet, dry it before the fire. When dry, they are to be starched. It is in this operation that the failures in getting up muslins and piqués more often occur than in the washing. Use a large basin and have plenty of starch, and dissolve in the starch, according to the quantity of it, 3 or 4 in. of composite or wax candle. Squeeze the starch well out of the dress, and while it is still wet put it between some old sheets or tablecloths, and pass it between the rollers of a wringing machine or under a mangle ; by this means all lumps of starch will be removed. Finish by ironing. Piqués should be ironed on the wrong side, as lightly as possible.

Flannel.—(1) To prevent shrinking in washing, soak the flannel for a night in cold water when dirty, and the next morning wash with curd soap in very lukewarm water. Don't wring, but press the water out and hang to dry. (2) Cleaning white flannel. Use pipeclay, which should be mixed to proper consistency in a pipkin ; stand on the fire till warm, stir with wax candle for 5 minutes, add a modicum of soap and a dash of Prussian blue, and stand by to cool, and always use cold, laid on with a sponge, and dry in shady breeze. For grease spots, lay over them pure clay, size the thickness of a crown piece, then place in the sun, and the clay will absorb all the grease without fail. When trousers are dry, rub them to loosen the clay, which brush off, and you will have cleaner looking trousers than by washing, and they will be fit to wear two or three times without pipeclaying. The same for flannel jackets.

Hearth-rugs.—Hearth-rugs should never be cleaned on the floor, but on a large scouring board, and should only be operated upon $\frac{1}{4}$ of their length at a time. After being cleaned, they require to be dried very quickly ; as otherwise, on account of the thickness of the pile, they are apt to sadden.

Hearth-rugs may be cleaned by either the first or second methods given for dry-cleaning carpets ; with the following exception, that when the first method is adopted, only 1 lb. of soap dissolved in 1 gal. of hot water will be required. After the rug is finished, dip a clean sponge into a pail containing a little common sour, and well rub it into the face of the rug.

Lace.—Cover an ordinary wine bottle with fine flannel, stitching it firmly round the bottle. Tack one end of the lace to the flannel, then roll it very smoothly round the bottle, and tack down the other end, then cover with a piece of very fine flannel or muslin. Now rub it gently with a strong soap liquor, and, if the lace is very much discoloured or dirty, fill the bottle with hot water, and place it in a kettle or saucepan of suds and boil it for a few minutes, then place the bottle under a tap of running water to rinse out the soap. Make some strong starch, and melt in it a piece of white wax and a little loaf-sugar. Plunge the bottle 2 or 3 times into this and squeeze out the superfluous starch with the hands ; then dip the bottle in cold water, remove the outer covering from the lace, fill the bottle with hot water, and stand it in the sun to dry the lace. When nearly dry take it very carefully off the bottle, and pick it out with the fingers. Then lay it in a cool place to dry thoroughly.

Shawls and Scarves.—China Crape, Brocaded or Printed Silk.—They may be cleaned by either of the methods, and in the same manner, as directed for silk dresses.

Woollen.—Scotch method : Scrape or cut up 1 lb. of soap, and boil it in a small quantity of water. When sufficiently cool, beat it to a jelly with the hand, at the same time mixing with it 3 tablespoonfuls of spirits of turpentine, and 1 of spirits of hartshorn. Wash the shawl thoroughly in this, then well rinse in cold water, and, when all the soap is out, in salt and water. This last need only be done when the shawl contains delicate colours. Then fold the shawl between two sheets, being careful not to let two folds of the shawl come together. Mangle, and afterwards iron with a very cool iron.

Sheepskin Rugs and Mats.—Dissolve 1 bar soap in 2 gal. boiling water. Put 2 qt. of this into a tub or pan containing about 2 gal. warm water. First rub out the dirt and grease spots with the strong soap liquor, or, if necessary, with fullers' earth. Then put the rug or mat into the tub containing the weak soap liquor, and well wash and punch it. Throw away this first liquor, and mix another lot with the same proportions of warm water and dissolved soap, and again well wash the rug ; and so continue until it is perfectly clean. Then rinse well in cold water to take out all the soap, and afterwards in cold water in which a small quantity of blue has been dissolved. This blue water will only be required for white skins. After this has been done, the mat or rug should be wrung out, shaken, and hung to dry with the skin side towards the sun, but not when the heat is scorching, or the skin will become hard and brittle. It should, while drying, be frequently shaken and hung up first by one end and then by the other.

Silk Handkerchiefs, Ribbons, Mantles, and Fancy Waistcoats.—Have 2 large earthenware pans, and put 2 qt. of camphine into each pan. Dip the article, whatever it may be, into the first liquor of camphine, well handle it in this, and repeat the operation in the second liquor. Then drain ; have a dry sheet on your board, lay the article on it, and dry well with fine cloths. Finish by ironing with a box iron.

Table Covers.—Dissolve 1 bar of soap in 4 gal. boiling water, and mix with it 1 lb. pearlash. Have 3 earthenware pans or tubs that will hold about 8 gal. each : into the first of these put

3 gal. of the dissolved soap and 1 pail cold water ; into the second, 2 gal. soap and 1 pail water ; and into the third, 2 pails water and 1 gal. dissolved soap. Well work the cover in each of these 3 soap liquors, beginning with the strongest, and wring it between each. Stir 1 tablespoonful of oil of vitriol into a tub containing 6 pails. cold water. Handle the cover in this spirit water for 5 minutes, then take it out and rinse it in one lot of cold water ; this is the proper method for cotton-and-worsted or printed cloth covers. Table covers made with a mixture of silk and worsted, instead of being spirited after cleaning, should be well worked in a pan containing 2 pails cold water, in which 1 lb. common salt has been dissolved, and afterwards rinsed through 2 lots of cold water. Dry quickly ; then shake, brush, and finish by ironing with a box iron, or send to the pressers to be finished.

Starch Gloss and Stiffener.—(*a*) 1½ oz. powdered spermaceti, ¾ oz. powdered gum arabic, 2 oz. powdered white starch, 1 oz. powdered borax. Powder spermaceti finely by aid of a little spirit of wine, add powdered starch and powdered gum, pass through a sieve and mix thoroughly with the powdered borax.

Directions for Use.—A teaspoonful to be added to each ¼ lb. of starch used, either hot or cold. (*b*) 30 oz. distilled soft water, 5 oz. pure glycerine, 2 oz. gum arabic, 2 oz. spermaceti, 3½ oz. borax powder.

Straw Matting.—(1) Wash with weak salt and water and dry well. (2) Boil a small bag of bran in 2 gal. of water, wash with this and dry well.

Tin, Scouring.—Petroleum or paraffin and powdered lime, whiting, or wood-ashes, will scour tins with the least labour.

Tobacco Pipes.—A very simple and effective plan. Cut ½ in. from the end of an ordinary cork, and fit it tightly into the bowl of the pipe. Then with a knife cut a hole through the cork wide enough to admit the nozzle of a water tap with a little pressure, turn on the water gently until the flow through the stem is sufficiently strong, and let it run until the pipe is clean.

Varnish (*and see* PAINT).—Mix a lye of potash, or soda, with a little powdered chalk.

Vellum.—Benzine applied with a sponge. It will remove almost every stain, and does not destroy the texture in the least.

Violin.—(1) Use soap and water, but avoid its running through the "*f*" holes. Clean the interior with *dry* rice. Do not use spirit. (2) Moisten the solid parts with salad oil, then mix same oil and spirits of wine together in a basin, trying its strength first on a part of the neck or scroll, then with a piece of white linen rag, dipped in the oil and spirit, rub the soiled parts, keep shifting the rag as it gets dirty : it will take several days to do, but keep the parts well soaked, where dirty, with oil after every rubbing ; but by no means scrape it. (3) Ordinary paraffin oil. *Slightly* saturate a rag of soft silk, and proceed to wash your violin therewith. The effect is almost magical ; the paraffin dissolves the crust of dirt and resin and cleans the varnish without injuring. (4) For the outside, a strongish solution of washing-soda, applied with piece of flannel. If you find the soda remove the varnish (as it does with some oil-varnishes), use soap-and-water, and then paraffin. When clean, rub with linseed-oil ; spirits of wine removes the old resin at once, but sometimes takes the varnish with it. For the inside, get a handful of rice, steep it in solution of sugar and water 5 minutes, strain off, and nearly dry the rice till just sticky. Put in at soundholes, and shake till tired. This will pick up all dirt, then turn out.

Violin Bows.—(1) Take a small piece of flannel, wet it (cold process), well rub it with best yellow soap, double it, holding the hair gently between the finger and thumb, rub gently till clean, using plenty of soap ; rinse flannel, wipe off, then wipe dry with a piece of calico or linen; in an hour afterwards it will be ready for the resin. (2) A solution of borax-and-water.

Wall-papers. — To remove oil stains, or marks where people have rested their heads, from wall-papers, mix pipeclay with water to the consistency of cream, lay it on the spot, and allow it to remain till the following day, when it may be easily removed with a penknife or brush.

Zinc Vessels.—Zinc articles, if small, can be cleaned by being pickled in spirits of salts (hydrochloric acid) with water added, till the articles are nicely cleaned, in about three minutes, without being too strongly attacked, then washed and dried. Large articles like refrigerators are cleaned by being rubbed with a swab, dipped in raw spirits, then washed with water, and finished with whiting.

* * *

CLOCK AND WATCH MENDING.

THE ordinary repairs that watches and clocks occasionally require are not beyond the ability of anyone possessing mechanical knowledge and, particularly, some dexterity at using delicate tools. It must not be supposed that ability, and even skill, in repairs will enable a person to make a clock or watch, for this requires study, experience, also tools and appliances seldom possessed by those undertaking repairs.

Clocks. *8-day, operated by weights.* —As far as the "going" part of clocks is concerned—and that is the part liable to injury and wear—the ordinary 8-day English house-clock may be taken as the type; and those operated by weights differ little to those having a spring as a motive power, except in the arrangement of the spring itself and its connections. These are described later.

The interior of an 8-day clock is shown in side section in Fig. 95: a rope is coiled round the barrel A, 16 times for the 8 days, and the barrel is fixed to its arbor B, a prolongation of which is the square winding pin that comes out on the face of the clock. The dial plate or face is fixed by small screws *a* or by sockets and pins *b*, to to some 4 or 5 legs *c* which join the front and back plates of the clock frame; frequently the dial is provided with a special set of legs of its own. On the arbor B also rides the great wheel C, which is connected with the barrel by the ratchet D. The great wheel drives the centre pinion *d* on the arbor of the centre wheel E, which is prolonged outside the dial plate and carries the "minute" or long hand *e*.

The centre wheel makes 1 revolution in an hour, and the great wheel 1 in 12 hours, by being provided with 12 times as many teeth as the centre pinion. The centre wheel drives the second wheel F by its pinion *f*, and that again drives the escape wheel G by its pinion *g*. If the pinions *f g* have each 8 "leaves" (the teeth of pinions are so called), E will have 64 teeth and F 60, in a clock whose escape wheel revolves once in a minute, so that the seconds hand may be set on its arbor prolonged to the face of the clock. The arbor *h* of the pallets of the escapement H goes through a large hole in the back plate near *i*, and its back pivot turns in a cock *j i k* screwed on to the back plate.

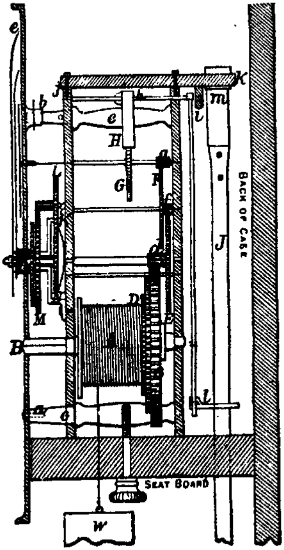

FIG. 95.

From the pallet arbor at *i* descends the crutch *i l*, ending in the fork *l*, which embraces the pendulum J, so that, as the pendulum vibrates, the crutch and pallets necessarily vibrate with it. The pendulum is hung by a thin spring *m* from the cock *k*, so that the bending point of the spring shall be *just opposite* the end of the pallet arbor, and the edge of the spring *as close as possible to the end of that arbor.*

Motion Work.—Of the "motion work" of the clock, the first thing to notice is the minute hand, which fits on the square end of a brass socket fixed to the wheel K, and sits closely but not tightly on the projecting arbor of the centre wheel. Behind this wheel comes a bent spring, which should be set on the same arbor with a square hole in the middle, so that it turns with the arbor. The wheel is pressed against this spring, and is kept there by a cap and a small pin through the end of the arbor: consequently there is sufficient friction between the spring and the wheel to carry the hand round, but not enough to resist a moderate push with the finger for the purpose of altering the time indicated. This wheel K, usually called the minute wheel, but is really an hour wheel, drives another L having the same number of teeth, and a pinion attached to it; this pinion drives the 12-hour wheel M, also attached to a large socket or pipe carrying the hour hand, riding (to relieve the centre arbor of extra weight) on an intermediate socket fixed to the bridge N, which is screwed to the front plate over the minute wheel K.

A heavy weight *w*, which drives the train, and gives the impulse to the pendulum through the escapement, is generally hung by a catgut line passing through a pulley attached to the weight, the other end of the cord being tied to some convenient projection in the clock frame or seat-board, to which it is fixed by screws through the lower legs.

Cases.—It is a common practice to make the cases of house clocks 6 ft. high; this is a great waste of space and materials. The case need only be long enough to give the pendulum full play, if the size of the barrel is diminished, or the great wheel is increased in diameter, or the weights are hung on a treble instead of a double line, at the same time increasing the weights in a progressive ratio to overcome the additional friction.

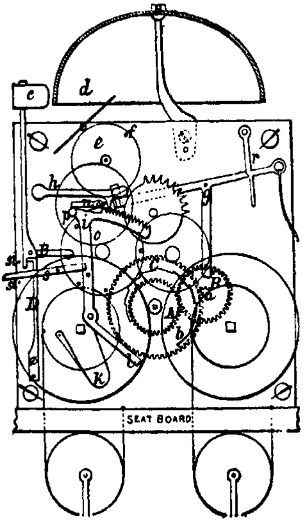

FIG. 96.

Striking Movement.—Fig. 96 represents a front view of the clock minus its face, thus exposing the repeating or rack striking movement. On the pipe of the hour wheel A the minute hand is set. B is the reversed hour wheel with its pinion *a*, driving the 12-hour wheel C, on whose socket is fastened a snail *b*, belonging to the striking work exclusively. The hammer *c* is raised by the 8 pins in the rim of the second wheel in the striking train; it does not quite touch the bell *d*, or it would cause a jar in striking. The spring D is arranged both to drive the hammer against the bell, when the tail E is raised, and to check the hammer just before reaching the bell, so that the blow on the bell is due to the hammer having acquired sufficient momentum to carry it a little beyond its place of rest. Occasionally one spring is used to impel the hammer and another to check it; the latter may be replaced by a piece of vulcanised rubber tied round the leg where the hammer shank approaches it. To reduce the chattering of a heavy hammer, make it lean forward so as to act partially by its weight.

As a rule, the pinion of the striking wheel has 8 leaves; and as a clock strikes 78 times in 12 hours, the great wheel will revolve in that period if it has 78 teeth instead of 96, which the great wheel of the going part has for a centre pinion of 8. The striking wheel drives the wheel above it once round for each blow, and that wheel drives a fourth *e*, on which is a single pin *f*, 6, or any integral number of turns for 1 turn of its own; that again drives a fan fly to moderate the velocity of the train.

The reversed hour wheel B is so adjusted that, within a few minutes of the hour, the pin in it raises the lifting-piece *g* so far that the latter disengages the click *h* out of the teeth of the rack *i*, which, helped by a spring *k* near the bottom, immediately falls back as far as it is permitted by its tail *l* coming into contact with the snail *b*. It is so arranged that the number of teeth which pass the click is proportionate to the depth of the snail; and as there is one stop in the snail for each hour, and it goes round with the hour hand, the rack always drops just as many teeth as the number of the hour to be struck. This drop makes the noise known as "giving warning." The clock is not ready to strike till the lifting-piece has fallen again: for as soon as the rack was let off, the tail of the gathering pallet *n*, on the prolonged arbor of the third wheel *o*, was enabled to pass the pin *p* of the rack on which it was pressing before, and the striking train began to move; but before the fourth wheel *e* had made half a revolution, its pin *f* was caught by the end of the lifting-piece, which is bent back and goes through a hole in the plate, and when raised stands in the way of the pin *f*, so that the train cannot go on till the lifting-piece drops, which it does exactly at the hour, by the pin on the wheel *e* slipping past it.

The train is then free. The striking wheel begins to lift the hammer, and the gathering pallet catches up the rack, a tooth for each blow, till it has returned to the place at which the pallet is stopped by the pin *p* coming under it. The lifting-piece is prolonged to E, where a string is hung to it; this is the proper place for such a string when it is wanted for the purpose of learning the hour in the dark. It is generally put on the click *h*; but in this case, if held too long the clock will strike too many, and if the string accidentally sticks in the case, the clock will go on striking till it is run down. The click *r* only exists in clocks which strike the quarters. The lever *s* controls the striking; if pushed up to *s i*, the other end will meet a pin in the rack and prevent the striking.

Repairing. — Having described and illustrated the mechanism of the 8-day clock, it will be an easy matter to give directions for effecting simple repairs.

After taking the movement from its case, removing the hands, dial, minute cock, and bridge, try the escapement with some power on, and note any faults there. Next remove the cock and pallets—putting a peg between the escape-wheel arms to prevent it from running down—and carefully let down the spring. Here sometimes you will meet with a difficulty; if the spring has been set up too far, and the clock is fully wound up, it may not be possible to move the barrel arbor sufficiently to get the click out of the ratchet. In many old clocks there will be found a contrivance to meet this difficulty. It is simply a hole drilled at the bottom of, and between the great wheel teeth directly over the tail of the click; so that you can put a key on the fusee square and the point of a fine joint pusher through the hole, release the click, and allow the fusee to turn gently back until it is down. This is a great convenience sometimes. Having let down the spring, try all pivots for wide holes, and if it is a striking clock, do the same with the striking train, paying particular attention to the pallet-pinion front pivot to see if it is worn, and the rack depth made unsafe thereby—also seeing that none of the rack teeth are bent or broken Having noted the faults, if any, take the clock to pieces, and look over all the pivots, and note those that require repolishing. Finally, take out the barrel cover, and see to the condition of the springs—if exhausted or soft.

Pallets.—In most cases, some repairs will be required to the pallets, as these nearly always show signs of wear first; if they are not much cut, the marks can be polished out without much trouble—and for this purpose you will find that a small disc of corundum about 3 in. in diameter, mounted truly on an arbor, and run at a high speed in the lathe, will be of great assistance; finishing off with the iron or steel polisher and sharp red stuff. If you have to close the pallets to make the escape correct, see that the pallet arms are not left hard, or you may break them.

After making any alteration in the pallets, you will generally find it necessary to correct the depth; should it only require a slight alteration, probably it will be sufficient to knock out the steady-pins in the cock, and screw it on, so that it can be shifted by the fingers until you have got the depth correct, then screw it tight and broach out the steady pin-holes, and fit new pins. Sometimes one meets with a pallet arbor that has been bent to correct the depth. This is a practice that cannot be too strongly condemned, as it throws an unequal pressure on the pivots, and causes them to cut rapidly. If much alteration in the depth is required, it may be necessary to put in a new back pallet hole; this can be made from a piece of hollow stopping broached out and turned true on an arbor, and to a length equal to the thickness of the plate. It is not safe to rely on the truth of this stopping, unless it is turned on an arbor first. The hole in the plate is now drawn in the direction required with the round file, and opened with a broach from the inside until the stopping enters about half way. Of course, in finishing broaching the hole, you will roughen the extremities to form rivets. Drive the stopping in, and rivet it with a round-faced punch from the outside, reverse it, rest the stopping on the punch, and rivet the inside with the pane of the hammer; remove any excess of brass with the file, chamfer out the oil sink, and stone off any file marks; finally opening the hole for the pivot to the proper size. If you have a depth tool that will take in the escape wheel and pallets, it will be quicker to put them in the tool, fill up both holes with solid stoppings, and replant them; but few workmen have a large depth tool.

Pinions.—Very frequently you meet with a scape pinion that has become so badly cut or worn as to be useless, and you cannot always purchase a new one of the right size; in this case it will be necessary to make it from the wire which you can always obtain of every size at the tool shops. In sectoring the pinion wire to the wheel, bear in mind that it will become slightly smaller in filing up. Considerable practice is required to make good-shaped pinions quickly and well. A piece of pinion wire of a slightly greater diameter than the pinion is to be when finished, is cut about ⅛ in. longer than required, and the position of the leaves or head is marked with 2 notches with a file. The leaved portion of the wire that is not required, is now carefully filed down on a filing-block, taking care not to remove any of the arbor in so doing; a centre is then filed at each end true with the arbor, and these centres are turned true through a hole in a runner or centre in the throw. If this has been carefully done, the pinion will be *nearly true; it is now set quite true,* and the arbor and faces of the pinion are turned square and smooth. The pinion is now filed out true, using a hollow-edged bottoming file for the spaces, and a pinion-rounding file for the sides of the leaves. In using the bottoming file, the pinion is rested in a gallows tool described, and held in the fingers for the leaves, when finishing to keep them flat.

The file marks are now taken out with fine emery and oil; the polishers used for this purpose are pieces of wainscot oak, about ¼ in. thick, 5 in. broad, and 6 in. long, used endway of the grain. One end is planed to a V shape to go between the leaves, and the other is cut into grooves by rubbing it on the sharp edges of the pinion itself, which speedily cuts it into grooves to fit. The pinion is rested while polishing in a groove cut in a block of soft deal, which allows it to give to the hand, and keeps it flat. When the file marks are all out, the pinion is ready for hardening. Twist a piece of stout binding wire round it, and cover it with soap; heat it carefully in a clear fire, and quench it in a pail of water that has been stirred into a whirlpool by an assistant, taking care to dip it vertically. Having dried it, it is covered with tallow and held over a clear fire until the tallow catches fire; it is allowed to burn for a moment, and then blown out and permitted to cool. The leaves are now polished out with crocus and oil in the same way that they previously were with emery.

Now, if the pinion is put in the centres and tried, it will probably be found to have warped a little in hardening. This is corrected in the following manner: The rounding side of the arbor is laid on a soft iron stake, and the hollow side is stretched by a series of light blows with the pane of the hammer, given at regular intervals along the curve. Having got the leaves to run quite true by this means, turn both arbors true, and polish them with the double sticks—these are simply two pieces of thin boxwood, about $\frac{3}{8}$ in. wide, and 3 in. long, fastened together at one extremity and open at the other; between these the arbor is pinched with oil and fine emery, and they are traversed from end to end, to take out the graver marks. The brass for the collet, to which the wheel is riveted, is now drilled, broached, and turned roughly to shape on an arbor. The position on the pinion arbor is marked with a fine nick, and the collet is soldered on with soft solder and a spirit lamp, taking care not to draw the temper of the arbor when doing so. Wash it out in soda and water, and polish the arbors with crocus, turn the collet true, and fit the wheel on. If the pinion face is to be polished, it is now done, the facing tool being a piece of iron about $\frac{1}{16}$ in. thick, with a slit in it to fit over the arbor with slight freedom, and using oil-stone dust first, and then sharp red stuff.

Generally, cut pinions are used for the centres, and in this case the body of the arbor is sufficiently large to allow the front pivot to be made from the solid arbor; but in some movements, particularly those used for spring dials, the centre pinions are made from pinion wire in the manner just described; but for the front pivot a hollow tube of hardened and tempered steel is soldered on to the arbor. This piece should always project sufficiently far through the pivot hole to allow it to be squared to receive the friction spring which carries the motion work. In cases where this pivot is much cut, it is best to remove this piece and substitute a new one, and as these pinions are very long and flexible, some difficulty will be experienced in turning this pivot unless some form of backstay is used to support the arbor, and prevent it springing from the graver.

In common clocks, where both third and escape pinions are worn by the wheel teeth, if the pivots are still in good condition, and the expense of new pinions is objected to, very good results can be obtained by the following alteration. The third pinion leaves must be turned back from the outer end rather more than the thickness of the centre wheel, the pivot shoulder also turned back the same distance, the pivot remade, burnished, and shortened. Then the pivot hole in the front plate is carefully opened with a broach to about twice its original size, and a stopping with a good large shoulder is turned true on an arbor and riveted into the plate. The thickness of the shoulder of this stopping will depend on the amount that you have shortened the arbor, and must be such as just to give correct end-shake to the pinion. By shifting the third wheel and its pinion thus, a fresh portion of both the third and escape pinions is brought into action, and as good results will be obtained as by putting 2 new pinions, with a very small expenditure of time and trouble.

Escape Wheels.—One often finds in old clocks that the escape wheel is so much out of truth that anything like close scaping is out of the question, as so much drop has to be given to enable some teeth to escape, that nearly all the power is lost; in such a case a new wheel is a necessity, and if you want to get a good hard wheel you must make the blank yourself. Take a piece of hard sheet brass, about twice as thick as the wheel is to be when finished, and cut from it a square sufficiently large for your wheel; then with a hammer with a slightly rounded face, reduce it to nearly the thickness you require. In hammering, go regularly over the surface, so that no 2 consecutive blows fall on the same spot; and when one side is done, turn it over, and treat the other in the same way. File one side flat, find the centre, and drill a hole nearly as large as required for the collet; cement it with shellac to a flat-faced chuck in the lathe, and centre it true by the centre hole. Mark with the graver the size of the wheel, and with a narrow cutter remove the corners; face the blank with the graver, and turn it to size, leaving it slightly larger than the old wheel; knock it off the chuck and reverse it, bringing the turned face next the chuck, turn that face flat and to thickness, and it is ready for cutting. After it is cut, remove any burrs with a fine file, and mark a circle to show the thickness of the rim, and on that circle divide it into the number of arms it is to have; mark also a smaller circle slightly larger than the collet on which it is to be riveted, draw lines through the divisions in the outer circle and the centre of wheel to mark the centre of the arms. Drill a hole between each 2 arms to enable you to enter the file, which to begin with should be a coarse round one, then follow with the crossing file, holding the wheel between a piece of thick card in the vice; finish by draw-filing the arms and crosses with a very smooth file, followed by a half-round scraper used as when draw-filing. This leaves the surface smooth and ready for the burnisher, of which tool two different shapes will be required, one oval, and the other half-round. These tools, when in use, require to be repeatedly cleaned on a piece of leather, and passed over the palm of the hand, to prevent tearing up the surface of the metal. The wheel teeth are now polished out with a short-haired brush and fine crocus and oil; then take out the file marks from both sides of the wheel with water-of-Ayr stone and oil, and it is ready for riveting on.

The riveting stake for clockwork is exactly like the ordinary pinion riveting stake used by watchmakers, only it is in 2 pieces dividing down the centre of the holes; if it were in one piece, the pinion head would prevent it passing through a hole of the proper size to fit the collet; it has 2 steady pins to ensure its coming together properly. Take a slight chamfer out of the front of the wheel hole, and roughen the surface of it with a graver, turn the collet down to fit in tightly, and rivet it on with a half-round punch, taking care to strike light blows and keep the wheel turning while riveting. It is then ready for stoning off and polishing with a flat wood polisher and fine crocus and oil. In crossing out a small delicate wheel, it is a good plan to fasten it with shellac to a flat plate of brass, having a hole in it rather larger than the inside of the rim of the wheel. In this way all danger of bending a tooth of the wheel accidentally is avoided, and the crossing can be finished without removing it from the plate.

A few hints on cutting escape wheels may be useful to those who possess a wheel-cutting engine.

The form of cutter used for brass wheels is what is commonly known as a fly, or single-tooth cutter, driven at a very high velocity. If the cutter is of proper form and well polished and the blank to be cut is firmly supported, the teeth cut will have a perfectly smooth polished surface, requiring no further finishing.

There are several forms of spindle in use to carry single-tooth cutters. The one shown in Fig. 97 is very convenient, and easy to make. A plain steel arbor 2¼ in. long and 5/16 in. diameter is centred, and turned down at the left end for a short distance, to receive the brass pulley by means of which the spindle is driven; the other extremity of the arbor is also turned down for a length of ⅜ in., to about ¼ in. diameter. A flat is filed

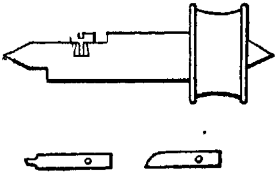

FIG. 97.

on one side of the arbor for nearly half its length, until it is level with the reduced extremity of the arbor. A taper dove-tail groove is then filed at right angles to the axis of the arbor and down to its centre to receive the cutter (this groove should taper so that the cutter enters tail first), and at the centre a hole is drilled, tapped, and a screw fitted as shown to secure the cutter in position. The extremities of the arbor are now hardened and let down to a full straw colour, the pulley is driven on and turned true, and both centres are finished to fit the centre screws accurately.

The cutters are made from square steel, carefully filed to fit the groove in the cutter spindle, and when properly fitted, knocked gently in with a light hammer; a hole is drilled to correspond with the screw hole in the spindle. The cutter is now filed out to the shape required, using the old wheel as a gauge; for a small engine, the cutter should not project more than $\frac{5}{16}$ in. beyond the arbor. The angle at which the cutter is sharpened must be but little less than 90° (if made more acute, the cutter will chatter and not cut a smooth surface); of course, in filing, the angle will be made less than this, but in the final smoothing and polishing it must be increased to this. After it is filed to shape, it is knocked out of the spindle, covered with soap, and hardened—the face rubbed bright and tempered to a straw colour—the shank being let down still softer to prevent its breaking. The flat side and face of the cutter are smoothed with oil-stone dust, and polished with either diamantine or red stuff on a bell-metal polisher, and the curved edge is done in the ordinary lever-end tool. Every portion of the cutting edge must be perfectly smooth and polished, or it will not produce a smooth surface on the wheel; when in use, if at any time the cutter is found to have a film of brass forming on the edge, it should be re-sharpened and polished at once. With a cutter of this description working on brass it will be found difficult to drive it too fast.

In adjusting the cutter in the engine, in order that the angle of the wheel teeth may be kept the same as in the original wheel, the old wheel is placed in position in the engine, and centred by the pump centre, then the cutter spindle is adjusted by its screws until the cutter passes freely between 2 teeth, when the set-screws are tightened. It will be found best, if accurate work is desired, to remove the greater part of the material at one cut, and then to finish with a very slight cut at last. The cutter must not be forced, but passed through at one uniform speed, rather too slow than fast, and kept liberally supplied with oil while cutting. If a cutter is required for a train wheel, some difficulty will be found in making one, so that both sides of the teeth are rounded alike, unless some special tool is made to ensure this; if only one or two wheels are to be cut, the following plan will give very good results with but little trouble.

A piece of steel having been fitted to the cutter spindle, as described before, a centre is formed at each end; fix a ferrule on it, and turn the end that is to form the cutter like a conical point of rather large size; making the pivot to just fill the space between two teeth of wheel of the size you require. The pivot is polished carefully and then a flat is filed down to the centre, leaving just half of the pivot —it will then be exactly like a half-round bit in section; it is hardened, tempered, polished on the flat, the end stoned off square almost, and that also polished. In making a cutter on this plan, the sides are of necessity exactly alike; the only disadvantage is that as it is sharpened by polishing the flat face only, it gradually gets smaller after being sharpened a few times.

The parts most frequently found to require repair in the striking trains of clocks, are the pivots of the upper pinions, especially those of the fly, pin wheel, and pallet wheel. If the points are only slightly cut, they can be re-turned and polished, and a new hole put in; but if to entirely remove the marks the pivot would have to be much reduced in diameter, a new pivot is the only resource.

In putting in new pivots, the best way of centring the arbor is to put a lantern runner in the throw, having a hole large enough to take the sloped-off shoulder in the arbor; then the arbor can be centred with the graver, and the drill started perfectly true. A short stiff drill should be used (fitted to a plain runner in the throw), ground to cut in one direction only, rather thin at the point, and quite parallel for a short distance behind the cutting angles. The drill should be left quite hard, or, if a soft arbor is to be drilled, it may be tempered to a light straw colour, and the rest of the shank rather softer. If this is lubricated with either turpentine or benzine, but little difficulty will be found in drilling the arbor; the hole should be rather deeper than the pivot is long, and in size rather larger than the pivot is to be. A piece of staff steel is now centred, hardened, blazed off, turned down true to fit the hole, and very slightly tapered (if too taper, the arbor will be split in driving it in); when it fits half-way in, draw-file it carefully, and cut it to length, filing the outer end off square. A few blows of a light hammer will fix it firmly in position, then the extreme end of the pivot can be turned to a centre, through a hole in the lantern runner. The pivot can now be turned down to size, polished, burnished, and the end rounded up. There are several tools sold for centring arbors for drilling, but there is no more accurate way than that described; as, if the hole should get out of truth in drilling, subsequent returning of the centre on the pivot end after it is inserted, corrects this. Should the pallet-wheel front pivot require repairing, a centre will have to be cut with the graver in the end of the square (as usually it is finished off almost flat at the end); then a male centre can be used, and the pivot turned and polished in the usual manner. This pivot is nearly always the first to show signs of wear, owing to the great strain on its locking, particularly in weight clocks.

Rack and Gathering Pallet.—In many old clocks, particularly in long-case striking clocks, the rack and gathering pallet are frequently found in very bad condition; the pallet perhaps fitting the square very badly, thus making its depth with the rack very uncertain. To make a new pallet is anything but a difficult matter; yet one seldom sees one properly made by the clock jobber. Frequently pallets are made of brass, a most unsuitable material for this purpose for English clocks, where the pallet not only has to gather up the rack, but also to stop the train at the conclusion of the striking. If the rack depth is planted as deep as it ought to be, there is not room for a very stout boss to the pallet, and nothing softer than steel should be used for this purpose in good work. In the absence of a proper forging, a pallet may be made from a square bar of steel, thick enough to give the requisite length of boss. Mark the length of the tail of the pallet, and file it down to almost the required thickness; file also the opposite face of the bar smooth and flat. Mark the position of the hole, and drill it at right angles to the face; the diameter of the hole will be the same as the small end of the square on the pallet pinion—measuring across the flats, of course. Start the corners of the square in the position you require them with a good square file; then take a piece of broken square file of rather a coarse cut, and of the same taper as the square on the pinion; oil it, and drive it in with a few light blows of a hammer, turn the pallet over and knock it out again, turning it a quarter round each time you withdraw it. In a few minutes you can thus form a good square straight hole, and fit it accurately to pinion-square.

Put it on an arbor, and turn the ends square and to length, see that the tail is at right angles to the hole, also file the boss to form and shape the lip. This is usually made straight and the back sloped off; consequently it scrapes the rack teeth with its extreme end only, and wears quickly. As the pallet is in reality a pinion with only one leaf, its durability is increased by curving the face similar to a pinion leaf cut in half. The end of the tail of the pallet should be rounded and finished off smoothly at right angles to its face, its length such that it is well free of the pin in the rack when gathering the last tooth but one, and rests fairly on the pin when the rack is up.

If the tail of the pallet were left quite straight, and the end filed off square, there would be danger of the rack being held up by the pallet, particularly when the pin in the rack is planted lower down than it should be, its proper position being rather above the top of the teeth. The tail of the pallet is therefore curved to just throw the rack off.

If any of the rack teeth are damaged at the points, it may be necessary to slightly top all the teeth and file them up again; only the backs, or curved sides of the teeth, should be filed, finally taking the burr off with the oilstone slip. In order to make the depth correct again, the rack arm is carefully hammered a little, to stretch it; great care must be taken to keep the teeth truly in circle, also to see that they are well free of the boss of gathering pallet—not only when it is in position resting on the rack pin, but also when it has moved into the position that it would be in when the clock has warned. If the boss of the pallet is not perfectly concentric, it may be just foul of the rack teeth in this position, although free when tried with the pallet resting on the stop pin. Sometimes this fault occurs in clocks that have been recently repaired, and, unless you suspect it, it is rather liable to escape detection, as workmen divide the run differently. Apparently, some consider this a matter of no importance, as you sometimes meet with clocks in which the hammer begins to lift as the clock warns, and a lot of useless run after the hammer has fallen. This is just the reverse of what should be the case, as the more run you get before the hammer begins to lift, the less probability there will be of the clock failing to strike when the oil gets thick.

Spring Tail to the Rack.—A frequent source of trouble in some old clocks is the spring tail to the rack; it is intended to allow the hands to set forward without allowing the clock to strike. If the spring is weak and the rack spring strong, it sometimes gives a little and allows the rack to fall lower than it should, consequently a wrong hour is struck; an excess of end-shake to the hour wheel will also cause this fault, if the snail is mounted on the hour-wheel pipe. This is, of course, easily corrected by the thicker collet in front of the minute hand.

Suspension Spring.—Another part that in ordinary clocks gets but little attention paid to it is the suspension spring for the pendulum. Any old piece of spring is generally considered good enough to make a suspension spring from, and the consequence is that one seldom meets with a spring that does not wind or twist more or less, it being almost impossible to straighten a curved piece of spring and keep it quite flat. If you wish to have the best material for this purpose, get some straight lengths of steel from the main-spring maker, of various thicknesses, and keep it for that purpose; they cost but little, and save time in grinding down, straightening, etc. The chops at the top of the spring are usually made by cutting a slit in a piece of brass of suitable thickness, and closing the slit down with the hammer upon the spring until it fits it.

A much better plan is to make the chops of 2 pieces of brass, and rivet them together with 4 rivets; the bottom edges should be slightly rounded off to prevent any chance of the spring breaking at that point, as it sometimes does if the edges are left sharp.

With regard to the strength of the spring, very few are met with that are too thin; but many err in the opposite direction, and are very much too thick. It is not always advisable to substitute a much thinner spring—especially should there be but little room for the pendulum to vibrate in, as sometimes the arc is so much increased as to cause the pendulum to strike the sides of the case, rendering it necessary to substitute a lighter weight or a weaker spring. The slit in the top of the pendulum is usually cut with a thin saw, and then closed with the hammer; but there is no certainty of keeping it straight this way, and it takes but little more time to file a true slot and fit a slip of brass to fill it up to the proper size, thus keeping the spring true with the rod.

For making new holes in the plates of clocks, many workmen use a punch which is more fit for a blacksmith, and hammer the plates about to close the holes which are worn. Instead of bruising the plates with such an instrument, why not go the right way to work, thus: cut off a piece of hollow brass wire (after it has been filed true and slightly tapering), open the hole, so that the wire can be driven tightly in; if you cut it off the proper length, so that it just goes through the plate, it is very little trouble to reknit in, and when the job is done, and properly chamfered, it looks neat, and is in every respect better than a hole which has been knocked out of the round, and often out of depths. With this little matter, the first trouble is the best, for even if the knocking or punching job does answer for a time, it soon gets worn again. This method is preferable for English, French, and American clocks. One way of putting teeth into wheels is to make a hole through the plate of the wheel immediately below the point from which the tooth has been broken. Let its diameter be a little greater than the width of a tooth. Next, with your tooth-saw, cut down where the tooth should stand till you come into the hole. You then dress out, with a head upon it, a piece of brass wire, till it fits nicely into the cut of the saw, with its head in the hole. With a fine graver you then cut a crease into the wheel plate above and below, on either side of the newly fitted wire; after which, with your hammer, you cautiously spread the face of the wire until it fills the creases, and is securely clinched or riveted into the wheel. This makes a strong job, and one that dresses up to look as well as any other.

The collet in front of the hands is a little thing, but it is seldom right; one that will hold the hands firm, and allow them to be moved small portions of space with ease and certainty. Before making a collet, first straighten the minute spring, and put it on its place on the centre pinion. Put the minute wheel on its place on the top of it, and then the minute hand on its place; now see the space there is from the surface of the hand to the pin hole in the centre pinion. Make the collet so high that it will just cover the hole, and then cut a slit in the collet just as deep as the hole is wide. Make the slit to correspond with the hole in every way, and in such a manner that when the pin is put in it will fit without shake. A collet made in this manner will last as long as the clock, and when the minute spring is set up, the hands will always be firm, and at the same time move easily, and not affect the motion of the clock when they are set backward or forward. The square on the pipe of the minute wheel sometimes projects through the minute hand, and the collet presses on it in place of the hand. When this is the case it should be filed down, because the minute hand cannot be held firm, unless the collet be very much hollowed at the back, which it is not always advisable to do.

Examination and taking to pieces.—The suspension of the pendulum, the pendulum spring, and the action of the crutch, or back fork, on the pendulum, are all of the most vital importance. The spring should be perfectly straight, and should fit into the slit of the cock without shake, and the slit should be perfectly straight, and at right angles to the dial of the clock. The back fork should fit easily and without shake, and the acting part stand at right angles to the frames. The pendulum bob should swing exactly in a plane with the frames and the dial. After a clock has been put in its case, before putting on the head, it is well to get up high enough and look down to see that all these parts work as has been described. Before taking the movement out of the case, it is advisable to see whether you can find out the immediate cause of stopping. The points to which to direct attention are: The hands, to see if they are in any way bound; the catgut lines, to which the weights are attached; the striking parts, to see if there is any mishap connected with them; and the pendulum, to see if it is free. If all these things are correct, and the clock appears dirty, conclude it wants cleaning, or that it needs some repairs which will necessitate its coming to pieces. Having satisfied yourself on these points, proceed to take off the 2 weights and the pendulum, and remove the movement to your work-board to undergo the requisite examination, cleaning, and repairs. Placing it, dial downwards, on the board, commence by unscrewing the screws by which the movement is fixed to the seat-board, and remove it. The bell-stud screw is now unturned, and the bell, bell-stud, and screw are placed on the board; then the bridge or "cock" screws and the pallets are taken out, and the cock is screwed back in its place. The cock is replaced, so that you may turn the movement over without fear of scratching the back plate, and it is left on till the last thing before the actual cleaning commences. The clock is now turned over face upwards, the small pin that secures the hands is removed with the pliers, and the collet or washer and hands are taken off. Pull out the pins that hold the dial, and remove it.

The movement consists of 2 distinct sets of "trains" of wheels, set within 2 brass plates, which are kept the proper distance apart by turned pillars. These are riveted to the back plate by one end, while the other ends pass through holes in the corners of the top plate, and are there secured by pins. One train of wheels and pinions constitutes the "going" part of the machine, and the other, with the various appurtenances connected with it, the "striking" mechanism.

The going train comprises the first or great-wheel and barrel, upon which the line runs; the centre wheel and pinion; third wheel, and pinion, and the escape wheel and pinion. The striking train comprises the striking great-wheel and barrel; pin wheel and pinion; gathering pallet, pinion, and wheel; warning wheel and pinion; and the fly and its pinion. The names of the other parts of the clock are the pallets and crutch; cock; pendulum; bell-stud and bell; motion work, embracing the cannon pinion, minute wheel, hour wheel, and snail; the hammer and hammer spring; lifter; detent rack; rack spring; rack hook, and gathering pallet.

The parts of a wheel are the teeth, the rim, the crossings, and the collet, or piece of brass on which the wheel is riveted. The parts of a pinion are the leaves or teeth, the arbor or axle, and the pivots which run in the holes.

Having obtained a good general idea of the mechanism, proceed to take the clock to pieces. Remove the motion-work and the various parts connected with the striking, which are under the dial; pull out the pins which hold the top plate on, take it off, and remove the wheels. Take off the hammer, tail spring, and the cock, and the clock will be ready for cleaning.

Cleaning.—Different workmen have

different methods of cleaning a clock, each supposing his own to be best; the following will be found as good as any. Mix up some rotten-stone with any good oil, and with a stiff clock-brush rub thoroughly over every part until all tarnish is removed. In brushing the plates, the brush must take one direction only, namely, lengthways of the plate, so that the scratches may appear in straight lines, otherwise it will look bad when finished. Should there be any rust on any of the steel work, it must be removed with fine emery cloth, and then rotten-stoned. Remove as much as possible of the rotten-stone and oil with an old duster, finish with a clean brush wetted with turpentine, and wipe dry with a clean duster. In cleaning the wheels, etc., care must be taken not to bend the teeth, or any other delicate parts; and not to rub sufficiently hard and long in one place to take off the corners and destroy the proper shape. Take especial care to clean out the teeth of the wheels, the leaves of the pinion, and round the shoulders of the pivots. The holes in the plates must also be well cleaned out with thin strips of leather, holding the plates in the bench-vice. Wrap a duster round the part that goes in the vice, unless the jaws are provided with lead clamps, so as not to mark the plates.

When every part is thoroughly clean it will be ready for "examining," by means of taper iron pins, with a loop formed at one end, for affording facility in picking them up off the board, and about 2 in. in length. To make them, cut off the required number of pieces of iron wire, and form the loops at the ends; put them one at a time in the hand-vice, and, resting the free end upon the filing-block held in the bench-vice, file them to the proper taper. Keep turning the pin round towards you, but only move it when the file is going in the opposite direction, that is, away from you. When filed to shape, they must be draw-filed with a smooth file, and finally burnished with a flat burnisher. A flat burnisher is simply a smooth piece of flat steel, and requires rubbing on the emery stick, so as to produce a grain cross-ways.

Renewing Wheel Teeth.—A much-recommended method of renewing wheel teeth is as follows: Proceed by fitting in a suitable piece of brass. Then procure a slip of zinc, drill a hole through it, and fit it tightly on the pinion or arbor on which the wheel is mounted. Secure it at a part where the teeth are sound, and cut it to the shape of the wheel; then with a slitting file or saw, cut out a pattern of 5 or 6 teeth more than you require in the new piece. When the zinc pattern is an exact copy of that part, bring it round to the new piece, allowing 2 or 3 of the zinc teeth to intersect with the wheel at both ends of the new piece. Fix it in this position and the new teeth may then be cut with the greatest ease and accuracy.

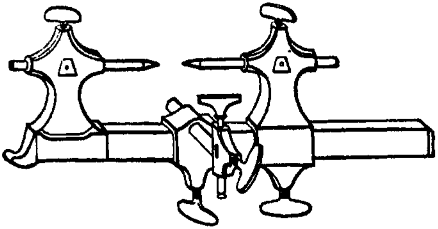
FIG. 98.

When a pivot is much worn or cut, if it will admit of it, it may be "run" (filed) down smooth and straight by means of the "turns" shown in Fig. 98. To "run" the pivot, fix the turns in the vice, and put in a female centre at one end, and a running centre at the other. Secure a screw ferrule upon the sound end of the arbor, and putting the point of the sound pivot in the female centre, adjust the position of the running centre, so that its groove receives the imperfect pivot, and allows it to have a good bearing. Put the gut of the cane bow round the ferrule in such a manner that the downstroke may cause it to revolve towards you; then, placing the plain edge of a fine file against the shoulder, file down the pivot until quite smooth and straight, taking care that with every downstroke of the bow the file is pushed away from you, and at the upstroke drawn towards you. Lastly burnish with a flat burnisher.

Escapement.—In repairing the escapement, reduce the friction by making the acting faces of the pallets very smooth and of good shape, avoid all excessive drop and consequent loss of power, and render it as free as possible from liability to the variation of the motive force. To examine the escapement, place the third wheel and escape wheel in the plates, and pin together with the examining pins. See that the pallets and crutch are tight on their arbor, and observe whether the pallets are worn by the action of the escape-wheel teeth. Put in the pallets, screw on the cock, and see whether the holes of the pallet arbor pivots are of proper size; it is very important that they should be only large enough for the pivots to be just free. If found to be too large, remedy at once by putting new ones; return the pallets to their place again, and proceed to test the action of the escape wheels upon the pallets by pressing forward the third wheel with one hand, and confining the action of the pallets by holding the crutch with the other, and then slowly moving it from side to side a sufficient distance to let each successive tooth "escape" the pallets. For the escapement to be correct, it should fulfil these conditions: The drop-on to each pallet should be equal, and only sufficient to give safe clearance to the tooth at the back of the pallet from which it has dropped; there should be as little recoil as can be obtained from the shape of the escape wheel; the pallets should not scrape the back of the escape-wheel teeth; and the faces of the pallets should be perfectly smooth, and of such shape as to require to be moved by the escape wheel before "escaping" a sufficient distance to ensure a "good action" or movement of the pendulum. As a general rule it will be found sufficient if the end of the crutch moves about ½ in. from drop to drop of the wheel teeth. If the pallets are worn, the wearings must be filed out, at the same time taking advantage of the opportunity to make them a good shape.

The escape wheels should nearly fit the wheel, when pressed into it on either side, as far as it is possible for them to go, the great object being to have as little recoil as possible. The first thing to be done before taking out the wearings, or altering the shape of the pallets, is to "let down" the temper. This is done by heating them to a cherry red, and allowing them to gradually cool again. Having thus softened them, file the wearings nearly out with a rather fine file, and alter to proper shape. Then smooth-file them, and lastly, with a bell-metal or soft steel rubber and oil-stone dust, finish them very smooth and free from file marks. They can now be hardened by heating to cherry redness and plunging into cold water, and afterwards tempered by warming till a part previously brightened with emery turns to a straw colour. If, upon trial, there is found to be too much "drop" off the outside pallet, on to the inside one, the pallets need "closing," or bringing closer together, which is best effected by placing them upon the jaws of the vice, opened to a suitable distance, and giving them a tap with a small hammer, so as to bend them nearer to each other. Take great care in doing this, and see that the pallet arms have first been softened by heating as before directed, or they will break. If there is too much "drop" off the inside pallet on to the outside one, the pallets require bringing nearer the wheel. If the excess is not very great, it may be conveniently altered by lowering the cock a little. To do this, remove the steady-pins from the cock, and move it round, so that the "drop" is corrected; then drill new holes in the plate for the steady-pins, so that the cock will be kept in its new place. When the drop is very excessive, new holes must be put in the back plate nearer to the escape wheel for the cock screws, and the cock lowered as much as is necessary to make the drop equal and correct. Fig. 99 shows the escape-wheel and pallets. The arrow indicates the direction in which the escape wheel revolves: *a*, outside pallet; *b*, inside pallet. Though it is proper to leave as little "drop" as possible, do not carry this to extremes; but remember to give sufficient to ensure clearance after a little wear, and under disadvantageous circumstances, or else after going a few weeks, the pallets will catch, and the clock will stop. When the edge of the inside pallet catches upon a tooth, the pallets are too close to the wheel; when the edge of the outside pallet catches, there is insufficient distance between the pallets. Some escape wheels are cut so irregularly that it is impossible to get a good escapement.

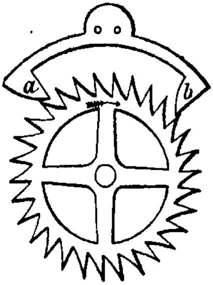

FIG. 99.

The opening in the crutch should be sufficiently large for the pendulum rod to move freely, with a little side-shake and no more; if at all rough inside, it must be made smooth and burnished, and then closed in to the proper size. See that the pendulum is sound everywhere; that the spring is not cracked or crippled; that the regulating nut and screw at the bottom act properly, and the bob slides easily on the rod. See also that its suspension is sound: it should rest well on the stud, and fit sufficiently tight as not to move at the top above the slit when swinging.

The striking train is generally examined before taking to pieces in a less critical manner; it is seldom so bad as to fail in striking, there being no resistance for the striking weight to overcome except the tension of the hammer tail-spring and rack spring, and the inertia of the train wheels. Should it be thought necessary, however, to be more careful, the course of procedure would be exactly similar to that described for the going train. The examination of the dial work is usually left until the clock is put together, as any errors can be easily altered, without in any way interfering with the rest of the clock. The plates are next carefully wiped with a clean duster; a leather strip is passed through the holes, and the wheels, pinions, and other parts are brushed clean, ready for putting together.

Putting Together.—Commence by screwing on the hammer spring and the cock. The cock is put on in order to allow the pivots to go through the holes until the shoulders rest on the plates, as the wheels do not fall about so much then as they otherwise would, and also to prevent the back plate being scratched by the workboard. Place the lower part of the plate towards you, and put the wheels, etc., in their proper places in the following order: Centre wheel, third wheel, two great wheels, hammer, pin wheel, escape wheel, gathering-pallet wheel, warning wheel, and last, the fly. Take care to have the catgut lines running the proper side of the legs or pillars. If there is an arbor for a "strike or silent" arrangement, put it in now. When these parts are in their proper positions, carefully put on the top plate, and pressing it moderately tight, guide the pivots into their respective holes, starting from the lower part of the frame. It is sometimes a great assistance to put the point of an examining pin into the holes of the lower pillars, when the top plate is on sufficiently far, as you have only then to attend to the top part. For the clock to look well when finished, there must be no finger marks upon any part; to avoid which, hold the plates, etc., with a clean duster when putting together, and keep it as bright as possible. When each pivot is in its place, and the top plate is resting fairly on the shoulders of the pillars, pin up with the examining pins, and test the correctness of the relative positions of the wheels.

There cannot, very well, be any mistake with the "going" train, but it is advisable just to press round the great wheel a turn or so, and see that all runs freely. The wheels of the striking train, however, require to be placed in certain arbitrary positions in regard to each other, except the great wheel and fly, which are exempt. The first position to be tested is that existing between the pin wheel and the gathering-pallet pinion. In order to do this, put on temporarily the rack, rack spring, hook, and gathering pallet. Let the rack hook hold the rack gathered up, with the exception of one tooth, and move round the pin wheel very slowly until the hammer tail just drops off; at that instant the tail of the gathering pallet should have about ¼ in. from the pin in the rack which stops the striking. If there is an excess of this, or if the hammer tail is resting on a pin, the top plate must be slightly raised, and the pin wheel moved a tooth farther on in the pinion until it is as near this condition as possible. The reason for making the striking chain cease running, as soon as can safely be done after the hammer falls, is that there may be as much run as possible before it has to raise the hammer and overcome the tension of the hammer spring. Under no circumstances leave the hammer tail "on the rise"—that is, resting on one of the pins of the pin wheel—when finished striking.

Having adjusted this, see that "the run" of the warning wheel is right. Put on the lifter, and gradually raise it till the rack hook liberates the train, and "warns." The distance the warning pin should run is half a turn, so that immediately before it "warns" it should be exactly opposite the piece on the detent, against which it is stopped, until the lifter falls and the clock strikes. See that the warning pin catches fairly on the stop-piece of the detent; if it does not, it is because the rack hook is raised either too soon or too late by the detent: alter as may be necessary. When the train is quite correct, remove the rack, etc., and pin up the plates finally with good-shaped pins.

It matters little what care may be bestowed upon repairing and cleaning, if the clock is badly pinned up, for no certainty of performance can be expected in such a case. Therefore make a proper shaped pin, not too thorny nor too straight, but gradually tapering, round and smooth, and well fitting the hole it is intended to occupy; then drive it in tight, and out off at an equal length each side of the hole. The front plate will now be ready for oiling.

Oiling.—To make an "oiler," file up a piece of iron wire something like an examining pin, but about 4 in. long, and then flatten out the end like a drill. A very good oil for house clocks is olive-oil. Pour some into some small vessel, and with the point of the oiler proceed to oil the pivots of the front plate by putting a little into each sink. A very little is sufficient, or it will flow over, and run down the plates, giving a very bad appearance. Slightly oil the studs upon which the rack and other parts work. The cannon-pinion spring may now be put on the centre arbor, and the cannon pinion and minute wheel in their places. They must work together in such a manner that the lifter falls exactly when the minute hand is upright; put the minute hand on the square of the cannon pinion, and see that it does so, or move the cannon pinion a few teeth in the minute wheel until right. The remainder of the dial work may now be put on, and the only items to observe are that the hour wheel works into the minute-wheel pinion, so that the hour hand is in its proper position when the clock strikes, and that the proportions and fall of the rack are correct. These are very important matters, and must be left exactly right, or the clock will be continually striking wrong.

Few clock repairers understand the proportion which should exist between the rack and rack tail. Fig. 100 will probably make the matter quite plain. To test the rack in its place, allow it to fall until the tail rests on the lowest step of the snail; the rack hook should then hold the rack, so that there are 12 teeth to be gathered up; then try it on the highest step—it should now exactly fit in the first rack tooth, leaving only that one to be gathered up. Supposing the clock strikes 13 when on the lowest step and 2 when on the highest, it shows that the end of the rack tail is a little too far off from the snail, and must accordingly be set a little closer. If, however, it strikes the right number when on the lowest step, and 2 when on the highest, then the proportion between the rack and rack tail is wrong; the rack tail travel being too great for the rack. To make the matter plain, suppose that we have to make a new rack tail, which is often necessary in badly used clocks. Measure first with a pair of spring dividers the proper distance that the rack teeth fall for 12 to be struck by the clock, and mark that distance on a piece of paper, as shown *b* to *a*; then take the distance from the points of the rack teeth to the centre of the stud, upon which the rack works, and mark that as shown *b* to *c*; then from *a* draw a straight line to *c*. Take the total distance the rack tail has to fall—viz. from the top step of the snail to the lowest, and from where the 2 lines, *a c* and *b c*, are that distance apart, to the point, *c*, is the length required for the new rack tail. In the diagram, the distance from the highest to the lowest step of the snail is supposed to be from *e* to *d*, therefore the length of the rack tail would be from *d* to *c*. When all is set right, pin on the dial, and put on the hands. There should be sufficient tension in the spring for the hands to move tolerably tight, or they will stop when the minute wheel has to raise the lifter. It is always best to use a steel pin to hold the hands on.

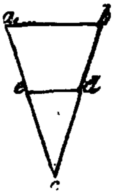

FIG. 100.

The clock is now turned over, and the pallets are put in. It is necessary to put a very little oil on the pallets where they touch the escape-wheel teeth, the pins of pin wheel, acting portions of the hammer spring, and crutch. See that the hammer acts properly on the bell; screw on the seat-board, and oil the pulleys.

Finally, put up the clock in the case. Fix the case as firm as circumstances will admit, then see that the seat-board has a good bearing, that the dial is upright and does not lean either backward or forward, and that the crutch is free of the back of the case. Hang on the weights, and wind them up carefully, observing that the lines run properly on the barrels. It sometimes happens that the line is longer than sufficient to fill the barrel, and, instead of forming a second layer across the barrel, rises perpendicularly, until it interferes with the clickwork. The best way to rectify this error is to put a piece of wire across the hole in the seat-board in such a manner as to throw it off as desired. Put on the pendulum, and set the clock "in beat." The meaning of "in beat" is, that the escape takes place at equal distances each side of the pendulum's centre of gravity. When the pendulum is at rest, it should require to be moved as much to the right before you hear the "tick" as it does to the left, and *vice versâ*. When "in beat" it sounds regular, and nearly equal, the differences of drop making it slightly uneven. The general rule for setting in beat is this: If the right-hand beat of the pendulum comes too quick, the bottom of the crutch requires bending to the right; if the left-hand beat comes too quick, then the crutch must be bent towards the left. The clock may now be considered finished. Regulation is effected by raising the pendulum bob to make the clock go faster, and lowering it to make it go slower.

30-hour English Clocks.—The manufacture of these clocks has entirely ceased; there are still a large number in use, however, which occasionally require cleaning and repairing. Two styles are met with: in one, the wheels are set within a square frame formed of several pieces, and known as "the birdcage"; in the other, the wheels are between 2 plates similar to the 8-day. There are 2 points of difference which require attention—the endless chain, and the striking mechanism. The endless chain must be put upon the spiked pulleys in such a manner that the wheels turn the right way when the weight is put on, and the part that requires pulling to raise the weight should always come to the front, so that the weight passes quite free behind it, Fig. 101. Sometimes the chains will be found to be twisted, and the links, gathering up into a knot, stop the clock. The way to rectify this is to draw up the weight separate the chain at the lowest part, let it hang free, straighten both pieces, and then unite again, when it will be found to work properly. A leaden ring, of sufficient weight to keep the chain just tight, is used to prevent the liability to twist. When a chain breaks from wear or rust, or jumps from being the wrong size, it becomes necessary to put a new one. They are made from iron wire.

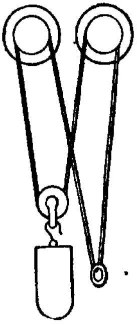

Fig. 101.

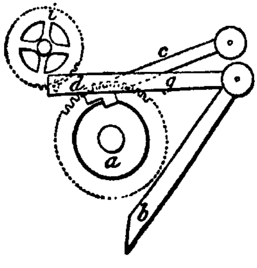

Fig. 102.

The most common kind of striking mechanism in 30-hour clocks is known as the "locking plate," and though it is more liable to derangement than the rack movement, still it is very largely used in French, American, and German clocks. It is much more simple than the rack, and one explanation of its construction will be sufficient for every case. The various parts are shown in Figs. 102 and 103: *a*, hoop wheel; *b*, lifter; *c*, hoop-wheel detent; *d*, warning detent; *e*, locking plate; *f*, locking-plate detent;

g, lifting pin to raise hoop-wheel detent; *h*, spring; *i*, warning pin. In testing the relative positions of the striking wheels when put together, proceed by moving the wheels round very slowly until the hammer tail drops off a pin; at that moment the hoop-wheel detent should fall into the hoop, so as to allow the hoop wheel about ½ in. run before it reaches the end of the detent, and stops the striking.

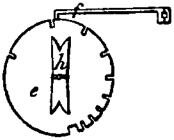

FIG. 103.

When the hoop is resting against the detent, the warning pin should have half a turn to run, the same as in the 8-day clock. The locking-plate detent *f* is connected by an arbor with the hoop-wheel detent *c*, and must be adjusted so that the latter can fall in the hoop wheel sufficiently far to stop the striking only when the end of the locking-plate detent falls into one of the notches of the locking plate. This is easily done by moving round the wheel to which the locking plate is attached, a tooth at a time, in the pinion that drives it, until it is in the correct position, and slightly bending the detent *f*, if necessary. When a clock with a locking-plate striking arrangement strikes till it runs right down, it is generally because the hoop-wheel detent does not fall freely, or the locking-plate detent does not enter the notches properly. It sometimes happens that the edge of the end of the hoop becomes worn and rounded by long use, and if the weight is excessive, it will cause the detent to jump out, and the clock to continue striking until run down. The remedy is obvious—file the end square. The locking plates are often cut irregularly; but on no account interfere by filing or spreading the edges, or perchance greater difficulties may arise, and there is always a position where it will answer well, which can easily be found by trial.

Spring Clocks. — The motive power of these timepieces being produced by the uncoiling of a spring, several parts are introduced which are not found in weight clocks—namely, the spring barrel, fusee, and stopwork. The cover of the barrel ought always to be removed when cleaning the clock, to ascertain the condition of the mainspring, and, if the latter is found at all dirty, it should be carefully removed with a pair of pliers, and cleaned with a little turpentine on a piece of rag. It may be replaced by winding it round its own arbor, which should be screwed in the vice by the squared end. Take hold of the end of the spring with a pair of strong pliers, and wind it as tight as possible; then slip the barrel over it, and carefully let go the spring, holding the barrel tight with the left hand until the spring has hooked. To try that it has hooked securely, before putting it back in the clock, put on the cover, secure the end of the arbor in the vice, and turn round the barrel until you can feel the spring is quite up. A new spring can be put in in the same manner. Always oil the main-spring after it has been handled. When a new barrel hook is required, select a piece of good steel, and file up a square pivot with a nicely fitting shoulder, and fit in the hole in the barrel; then shape the hook, and rivet in its place.

The fusee is liable to accidents to the clickwork, and when a chain is used, to breakage of the chain hook-pin. There are 2 kinds of line used to connect the fusee with the barrel—catgut and metallic. Metallic lines wear better, look better, and are quite as cheap as gut. To ascertain the length required for a new line, fix one end in the fusee, and wind the line round in the groove till it is filled up; then allow a sufficient length beyond to go round the spring barrel 1½ turn. When catgut lines are used, they should be slightly oiled. The method of fastening the ends is so simple as to need but little description. The fusee end is passed through the hole in the fusee, and tied in a simple knot, the end being slightly singed to render it less liable to slip. The barrel end is passed through the holes in the barrel in the following manner: Down through the first hole, up through the second, and down through the third; the end is then pushed through the loop formed by passing the line through the first and second holes.

Take special care, in putting together, to see that the line is free, and on the right side of the pillars. When ready to put the line on in its place, wind it upon the spring barrel by turning the arbor; and when it is all on, and the fusee pulled round as far as it will go, set up the spring one turn, and secure the click in the ratchet. Wind the clock up, carefully guiding the line on the fusee, and see that the stopwork acts properly, and does not cut the line when it rubs against it. The snail in the fusee should catch against the stop directly the fusee grooves are filled up with the line.

Musical Clocks.—These call for no special remarks, beyond that it is advisable to well understand the action of the "letting off" work, and the "run" allowed, before taking to pieces. The arrangements are so different that scarcely 2 are exactly alike; but they seldom offer any great difficulty when ordinary care is taken. It is wise in some cases to keep the striking and chime parts distinct while cleaning. Most of these clocks present favourable points for improvement by reducing the friction, and, when it can be safely done, it is well to do it; for, though the weights are unusually heavy, there is generally no power to spare.

Outdoor Clocks.—In the case of large clocks, the cause of stopping is usually apparent, and by trying the side-shake of the pivots in their holes, it can be readily seen if any new ones are required. The depths are nearly always correct, and the end-shakes can be tried the last thing when put together. There are 2 ways of treating such clocks: one consists of cleaning them as well as it is possible with emery cloth, and turpentine upon a brush, without removing any of the wheels from the frame, called "wiping out"; the other, in taking them all to pieces and thoroughly cleaning, in the same manner as small clocks. Which method is necessary or desirable must be decided by judgment. It will be found usually sufficient to thoroughly clean them about every 5 or 6 years, and "wipe them out" once every year—about autumn being the best time, before the cold weather sets in to influence the oil.

If the clock drives one or more pairs of hands, it is very necessary to see that the leading-off rods and universal joints do not bind in any part of their movement. When the dial work stands in a very oblique position in regard to the driving wheel of the train, it is often much better to use bevelled wheels than the ordinary leading-off rods and universal joints, and small-sized straight-drawn iron gas-tubes will be found very serviceable for making the connections, by simply fitting turned pieces of steel into the ends, to carry the wheels.

After a new hemp line has been put to a turret clock, if continued wet weather follows, it will oftentimes be found to twist and gather round so much as to stop the clock. The way to remedy this is to take the weight off, straighten out the line, and then replace it, giving it a few turns in the opposite direction to its twist. If this fails, as it sometimes does, the following plan will be successful: Mix together about ½ lb. soft soap and a packet of blacklead until incorporated, and work it well into the rope along its entire length, laying it out in one long straight line, and quite free to turn during the operation. It is rather a dirty job, but very efficacious, and well repays the trouble when hemp ropes are used; it hardens the rope, making it last longer and work better,

Drum Timepieces.—These seldom go satisfactorily for any length of time with the treatment they ordinarily receive. In addition to the usual careful examination of depths, end-shakes, sizes of holes, etc., it is necessary to bear in mind the following principal causes of their bad performance—defective calibre, roughness of finish, and faulty escapements. Defective calibre is unalterable, for you cannot prudently make any useful alteration in the proportions of the various parts, as the expense would probably be more than the timepiece would be worth. There is, however, one very important part which demands attention, and that is the mainspring. This usually has to make such a large number of turns for the timepiece to go the prescribed 8 days that considerable skill is required to make an escapement which will give a fairly uniform rate. Therefore it is always desirable to have a thin mainspring, in order to obtain as many turns as the size of the barrel will admit.

Rough finish must be remedied, especially in the parts farthest from the motive force. To this end, thin down the third, fourth, and escape wheels, when found unnecessarily thick, by filing with a fine-cut file, and finish smooth with a piece of water-of-Ayr stone. Take care not to raise a "burr" by using too coarse a file, and look out for imperfections in the teeth. If the pivots of the escape pinion and pallet arbor are left any too large, reduce their size by "running" in the turns, and burnish them well.

In these timepieces, faulty escapements are almost invariably found, and may be considered their greatest defect. With the object of rendering the pendulum insensitive to the varying power of the mainspring, the pallets are made as close to the arbor as possible, embracing only 1 or 2 teeth of the escape wheel. The inside pallet communicates impulse to the pendulum, but the outside one, forming part of a circle struck from the centre of motion, gives no appreciable impulse, as the escape-wheel teeth merely rest "dead" on it. Unfortunately, this principle is carried too far, and the result is that at times there is insufficient force at the escape wheel with such a small amount of leverage to maintain the vibrations of the pendulum, and the timepiece stops. As no beneficial alteration of the original pallets can be made in a proper workmanlike manner, it is best at once to condemn them, and make a new pair. By very carefully following the instructions here given, no great difficulty will be experienced in making them give favourable results. The object of making new pallets is to obtain a longer leverage, so that the occasional diminished force may prove sufficient to keep the pendulum vibrating; and the difficulty which arises is to make them of such a shape that this varying power of the escape wheel does not influence the time of the pendulum's vibrations, however much it may the extent. The object is attained by making the pallets embrace a larger number of teeth, which brings them a greater distance from the centre of movement, and thus increases the leverage. The difficulty is overcome by making the pallets of such a shape that the escape-wheel teeth rest as "dead" as possible during the excursion of the pendulum beyond the distance necessary for the escape to take place. From a consideration of the shape of the escape-wheel teeth, and the distance the pallet arbor is pitched from the escape wheel, it will be readily seen that, though the outside pallet can be easily made to give the desired effect, it is impossible to make the inside one of any shape that will not produce more recoil than is desirable.

To render this recoil as insignificant as circumstances admit, great care must be bestowed in suiting the pallet to the wheel, and for the same purpose it is advisable to make it nearer than the outside one to the pallet arbor. Before making the new pallets, file off the old ones, guarding the pivot so that the file cannot slip and break it off, and leaving the arbor round, smooth, and slightly taper. Procure a small piece of card, and make a straight line down the centre; then, with a pair of compasses, take the distance from the escape-wheel pivot-hole to the pallet-arbor pivot-hole, and make 2 small holes through the card upon the straight line that distance apart. In one of these holes fit the escape-wheel arbor so that the wheel rests flat upon the card, and in the other fit the pallet arbor. The number of teeth most suitable for the new pallets to embrace must be decided by the character of the train; if it is fairly good, 4 will be found sufficient; if very rough, 5 had better be the number. Select a piece of good steel, of suitable thickness; having softened it, drill a hole through it, and fit the pallet arbor in to the proper distance. Put the escape-wheel arbor through one of the holes in the card, and the pallet arbor with the piece of steel on it in the other, and see how much requires filing off, so as to leave only sufficient to make the pallets of the proper length. Now mark off the position of the opening between the pallets, the distance of the inside pallet from the line of centres being equal to the space between 2 of the escape-wheel teeth, leaving the space between the points of 3 teeth on the opposite side of the line of centres. Fig. 104 shows the escapement. It is advisable not to file out the full width until the pallets are roughly shaped out and ready for escaping. They should be made of the shape shown, keeping them flat across the surface; and they may be roughly "scaped" for trial upon the card, which, by bending, can be made to move the pallets nearer or farther off as desired. When nearly right, finish the escaping in the frame, taking great care not to get too much drop on to the inside pallet, as there is no way of altering it should there be an excess. The drop on to the outside pallet is easily adjusted, as the hole in the front plate is in a movable piece, which can be turned with a screw-driver.

Respecting the shape of the inside pallet, it will be seen that its point resembles a half tooth of an ordinary wheel; this is to cause the friction and recoil, which are unavoidable, to take place, with the least impediment to the pendulum, as this shaped-point rolls upon the faces of the escape-wheel teeth, whilst the ordinary form scrapes them. When the pallets are properly "scaped," it only remains to finish their appearance in a workmanlike manner, and harden and temper them. The sides should be nicely "greyed" by rubbing them on a flat piece of steel with oil-stone-dust and oil, and the acting faces polished with diamantine or redstuff. It will be generally found sufficient to secure them by driving the pallet arbor in tight; but if thought necessary, they may be pinned on. The timepiece may then be cleaned and put together, observing that it is nicely "in beat," according to the conditions already stated.

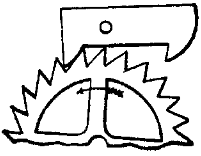
FIG. 104.

When these drum timepiece movements are fitted into large gilt or bronze cases, where there is plenty of room for any motion the pendulum may take, it is a great improvement to suspend the pendulum with a spring, for the pallet-arbor pivots, being relieved of the dead weight of the pendulum, do not wear the holes so quickly, and, as the friction is considerably reduced, the pendulum is kept in motion with less power. The best way to put a spring suspension is as follows: If there is sufficient substance in the cock above the pivot hole, drill a hole through the cock and tap in a piece of $\frac{3}{16}$-in. brass wire, with a slight shoulder, and rivet it in secure. Cut off so as to leave it about ½ in. long, and make a saw-cut to receive the brass mount of the pendulum spring. The underneath part of this stud should be left nearly in a line with the centre of the pivot hole. When the pivot hole is too near the top edge of the cock to allow this to be done, a piece of brass must be fitted on to the cock to receive the stud; a very convenient shape is shown at *a* in Fig. 105. Procure one of the thinnest and most suitable French clock pendulum springs, fit one of the brass mounts into the saw-cut in the stud, and arrange it so that the spring, when in action, may bend as near as possible in a line with the centre of the pivot hole; then drill a hole through the stud and brass mount, and secure it with a pin. Fit a steel pin on which to hang the pendulum, in the hole through the other brass mount. The pendulum rod should be a piece of straight, small-size steel wire tapped with a thread at both ends. Make the hook exactly like the ordinary French clock pendulum hooks, only very much smaller and lighter, and fit it on one end of the pendulum rod; screw the pendulum bob upon the other. Cut the old pendulum-rod in two, so that the piece remaining attached to the pallet arbor reaches to opposite the centre-wheel hole; file a short pivot on the end, and fit on it a crutch. All the parts must be as small and light as possible, and the pendulum-bob must be round and turn tolerably tight. Silk suspensions are sometimes used, but rarely give satisfactory results, as they are so sensitive to atmospheric changes.

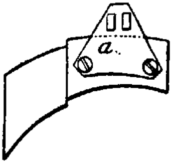

FIG. 105.

Bird Clocks.—These often give trouble from the bad mechanical arrangement of the parts. The great secret in repairing them is to reduce the friction as much as possible. The resistance to the rising of the "lifter" is often enormous, and may generally be reduced very much.

The mechanism of the cuckoo clock, as usually met with, is shown in Figs. 106 to 109. There are 3 distinct movements to be considered: (1) for the production of the sounds; (2) the appearance and retirement of the bird; (3) the movement of the wings and beak.

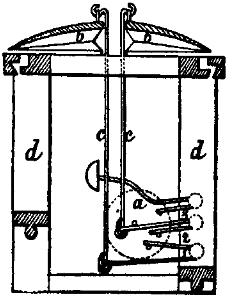

FIG. 106.

Fig. 106 shows the first. The dotted circle *a* represents the position of the pin wheel set within the frame, the pins of which have to raise 3 levers. Those numbered 1 and 2 raise the bellows *b*, and 3 corresponds to the ordinary hammer tail. The bellows are connected with 2 small "stopped" organ pipes *d*, measuring externally about 6 in. long and 1 in. square; and the "stops" are pushed in till the right note is obtained. The bellows are about 2½ in. long by 1½ in. wide, and are connected with the lifting levers by the wires *c*.

Fig. 107 shows the second movement: *f* is the hoop wheel, and *g* the detent, which, falling in the notch, stops the running of the striking train. *h* is a wire lever attached to the arbor of the detent, and moves with it. *i* is a vertical arbor carrying a piece *j* at right angles, on which is fixed the bird on the perch *k*. A spiral spring *l* keeps the short lever *m* in proper position, to be acted upon by the long lever *h*. As shown in the sketch, the cuckoo would be in; when the clock strikes, the detent *g* rises to the edge of the hoop wheel, moving the vertical arbor *i* with it, and the cuckoo on the perch *k* opens the door by means of a wire link, which unites the perch with the door. The bird remains out until the locking-plate detent allows the detent *g* to again fall into the hoop wheel, when the spiral spring *l* causes the bird to retire and close the door.

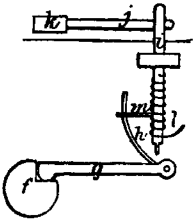

FIG. 107.

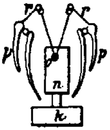

FIG. 108.

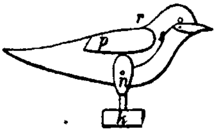

FIG. 109.

Figs. 108, 109, show the mechanism of the cuckoo. The body of the bird is hollow, and *n* is a block of wood in the centre of the body, firmly fixed upon the perch *k*. A pin *o* passes through the bird and block of wood, and serves for an axis, upon which the bird works when the tail is raised. The lower part of the beak is pivoted, and has a piece of wire attached; a wire projecting from the fixed wood block *n* terminates in a small ring which embraces the wire of the bill. When the tail is raised, the head lowers, and the beak opens. The flapping of the wings *p* takes place in a somewhat similar manner; they are united to the body by wire-ring joints at *r*, and a short wire lever is fixed in the upper edge of the wings. The end of this lever is joined by a ring joint to a fixed wire on the block. When the tail is raised, and the body moves farther from the centre of motion, the wings open; when the tail is lowered, they close. A piece of wire, fixed in the tail, is bent until exactly over one of the bellows. When the bellows are raised, they lift the wire of the tail, and thus cause the beak to open and the wings to flap. In putting the train together, be careful to have neither of the levers resting on the pins when finished striking; and make the other parts work easily.

German Clocks.—When of the ordinary construction, these call for no especial remarks; the principal point to notice is the back hole of the pallet arbor, which will be generally found much too large. It is an easy matter to put a new one.

American Clocks.—Try the pinions to see if they are tight on the arbors, for they are often loose. The best way to secure them is with a little soft solder, taking great care afterwards to thoroughly clean off all the "tinning" fluid with chalk and water; finally oil them slightly all over. When the pendulum wobbles, it is owing to the spring being crippled, or loose in the stud, or to want of proper freedom in the crutch. One authority remarks that when the pinions of American clocks are worn, the quickest way to remedy them is to carefully turn each wire round, then add a small piece of solder to each; use rosin instead of salts for the soldering, then there will be no fear of the pinion turning rusty. This method, in some respects, is preferable to putting new wires; as, if a novice does the job, he is liable to push in wire that is much thicker than is required, which, of course, causes a bad depth. When American pallets are worn, the simplest way to move them is to get the centre of a Geneva hand and put behind the pallets, which will, in most cases, move them sufficient for them to act on an entirely new part. When the brass holes get worn, it will sometimes be well to open them, and solder in a piece of hollow brass wire; then open the wire to fit the verge pin. This is better than wasting time trying to close the old brass holes.

French Clocks.—The cleaning and management of these clocks is simple. It occasionally occurs in new clocks, that a movement has been fitted to a case that is not high enough to allow the pendulum to swing free when the clock is regulated to the proper time. Sometimes filing a little off the bevelled edges of the ball will allow the pendulum to clear the bottom of the case or stand of the clock, and allow it to be brought to time. Should more than a little be required taken off the edge of the ball, there is no use troubling with it further. Either get a new movement, or alter the train, or make a new pendulum ball of a peculiar shape. The train is easiest altered by putting in a new escape-wheel pinion containing one leaf less than the old one. In all cases, where pinion wire can be had, putting in a new pinion is not much trouble; but if this cannot be done, and a new movement cannot be had, a new pendulum ball of an oblong shape may be used.

As soon as new clocks are unpacked, whether they appear in good condition or not, it is always well to take the movements to pieces, and to examine every action in the clock. Begin by taking off the hands and the dial, first trying if the hands move freely. Then examine the drops of the escapement to see if they are equal; if not, they can easily be corrected by moving the front bush of the pallet arbor with the screw-driver, making a light mark across the bush with a sharp point, which will show how much the bush has been moved. The fly pitching may next be examined and adjusted by the movable bush in the same way. The object of this bush being left movable is to admit of the depth being adjusted, so that the fly will make the least noise possible, and also to regulate the speed of the striking train. The dial work and the repeating work, if any, may now be removed and the springs let down, the end and side shakes of the pivots in their holes carefully tried, and all the depths examined; as a general rule they will be found to be correct. The pivots, will in some instances be a little rough and it will not be much trouble to smooth them.

After examining the mainsprings, and noticing that the arbors are free in the barrels, the clock may be cleaned, and put together. This will be most conveniently done by placing all the wheels first on the back plate, and putting the front plate on the top. Get all the long pivots into their holes first, and as soon as possible put a pin into one of the bottom pillars. The locking of the striking work of these clocks is very simple, and all the pieces are marked.

Be sure that the arbors in the barrels are oiled, and that the mainsprings are hooked before you put them in the frame. See that there is oil on the pivots below the winding ratchets before they are put on, and that the wheel which carries the minute hand moves round the centre pinion with the proper tension, before you put on the dial. This cannot be remedied after the dial is put on, without taking it off again, and if the hands are loose, results fatal to the character of the clock are sure to follow.

To regulate the clock, it is safest to turn the case round, examine the regulator, and, if it is a Breguet, put a slight mark with a sharp point across the regulator. When the regulating square is turned, you will see exactly how much the regulator is altered; because there is sometimes a want of truth in the screw that moves the sliding piece, which deceives people as to the distance they may have moved the regulator. There are various kinds of regulators, but probably the Breguet is the most common of those of modern construction. Silken thread regulators should always be regulated with caution, and when small alterations have to be made, it is well to use an eye-glass and notice how much the pendulum is moved up or down. If a clock with such a regulator has to be moved or carried about, when it is out of the case, it is always best to mark the place where the pendulum worked in the back fork, when it was regulated to time; for should the thread be disarranged, it can be adjusted so as to bring the mark on the pendulum to its proper place, and the regulation of the clock will not be lost thereby.

When fastening the clock in its case, put it in beat by moving the dial round a little till the beats become equal; but it sometimes occurs that when the clock is in beat, the dial is not square in the case. When this happens take the clock out of the case and bend the back fork at its neck till it moves exactly as far past the centre-wheel pivot on the one side as on the other, when the pallets allow the escape wheel to escape. If this is done, the dial will be square when the clock is in beat. Some French clocks have their back forks loose, or rather spring tight, on their arbors. This is sometimes done in movements that have plain as well as jewelled pallets. If the pallets are exposed in front of the dial, you can at once detect by the eye, if the clock be out of beat; but if they are inside, you cannot tell without close listening. One of the objects of the loose crutch is that the clock can be put in beat by giving it a shake; but it is evident that if a shake puts it in beat, another shake will put it out of beat again. Great annoyances arise from these loose crutches; these ought always to be rigidly tight, except, perhaps, when the pallets are jewelled, or when the clock is not liable to be moved.

These clocks seldom require any repair, except perhaps the pallets get cut; but they are generally made so as to admit of the action being shifted, which is easily done. Cleaning the brass is done in the usual way. Buffs should be used for the large pieces, when very dirty; but if they are only slightly tarnished, a little potassium cyanide dissolved in alcohol will be found very suitable. The ornamental cases require to be handled with care, to prevent finger marks. In the highest priced clocks this precaution is perhaps not quite so necessary, because then the cases are either real bronze, or gilt and burnished; but in the cheaper qualities, and also in some expensive patterns of cases, the gilding is easily damaged. A little potassium cyanide and ammonia, dissolved in water, will often clean and restore it, if the gilding is not rubbed. There is a preparation sold in the form of a paste that renews the lustre of black marble cases, if they have become dim. If the preparation cannot be got conveniently, a little beeswax on a piece of flannel may replace it.

Watches.—In setting to work upon repairing a watch, it is of great importance to adopt a regular system in submitting it to examination, always following a certain order in dealing with the various parts. This will obviate the risk of omitting some parts altogether and inspecting other parts more than once. The work is performed with the aid of the following implements:—

The "Workboard" should be made of well-seasoned wood, rather large than small, and securely fixed at a convenient height in a good position as regards the light. Along the front edge should be a strip or "bead" of wood standing up about ⅜ in., and at the ends and back pieces 4–8 in., may form the border. Hooks and nails may be driven in these wide pieces for holding tools and other things. Those who have limited space use a portable tray, with a similar border, which can be placed upon any table when required. The principal point to be attended to is that there are no cracks or crevices of any kind.

The "verge stake" is a round piece of steel, with a small narrow slit in the centre, mounted in a brass block used for resting the brass collet of a verge upon, whilst the balance is riveted on.

The "pinion stake" is a piece of brass or steel, about 2 in. long, with a number of graduated holes drilled in it, used for resting pinions on, when the wheels need securing or mounting anew.

The "bumping-up stake" is a steel stake, either round, square, or triangular at one end and hollow at the other; the solid end being used for hammering work on, and the hollow end for resting wheels and balances on when the arms require slightly bending by a gentle tap with the hammer.

The "pin vice" is a miniature vice with a long tail, by means of which it may be easily twirled between the thumb and first and second fingers.

The "filing-block" is a small piece of box-wood, used for resting wire upon whilst it is filed up into pins.

The "sliding tongs" is a tool somewhat resembling a stout pair of pliers with straight handles, having a slide upon them by which the jaws may be tightly closed.

The "chalk box" is a little box for holding a lump of chalk upon which to rub the brushes used in cleaning, to free them from grease and dirt. It may be made by nailing up a small box 3–4 in. square underneath the workboard, with a small piece of wood to prevent the chalk falling out in front; or by fixing a piece of wood from the right support to a place underneath the workboard, when the chalk will wedge itself sufficiently firm for the purpose.

The "mainspring winder" is a tool used for winding up a mainspring, so that it may be easily placed in the barrel.

A double-ended pair of brass callipers, with a small sink made in each end of one pair of arms; and a sink and a short male centre opposite, in the ends of the other pair of arms; they are used for testing the truth of wheels, balances, etc.

Of burnishers, one flat and one oval will be necessary for burnishing the pins which hold the frame together, and other purposes.

Very diminutive screwdrivers, made of small steel wire and fitted into a brass wire handle, are used for turning jewel screws.

A small sewing-needle, fitted into a piece of brass wire for a handle, filed down very fine, and then slightly flattened at the point, so as to take up a very minute quantity of oil, is used for oiling the watch.

"*Pivot broaches*" are exceedingly fine taper pieces of steel—some round, others hexagonal—used for making pivot holes a little larger, or hardening the acting surface of them.

"*Bottoming broaches*" are small tools, something like the preceding, only that they are "4-square," and intended to cut only at the point or end.

A set of bench keys, or of variously sized keys of the ordinary sort, bench vice, eye-glass, tweezers, watch pliers, nippers, screwdrivers, round and flat faced hammers, 2 brushes, oil-cup, knife, 2 or 3 files, covering glasses, French chalk, pegwood, tissue paper, pith, a cork or two, and 4 small examining pins, complete the equipment.

In examining a watch, take it in hand, and opening the bezel, attend to the following points before taking the movement out of the case. See that the enamel dial is not cracked or broken ; that the hands fit properly, are of the right length, and quite free of the hole in the dial ; that the cannon pinion is free of the glass, and that the seconds pivot is not too long and also free of the hole in the dial ; that the joint pin fits tight ; that the bolt and spring act correctly ; that the cap is clear of the case when opening the movement, and comes freely from the frame when taken off ; and that the winding-square is free of the case. Having done this, push out the joint pin, and carefully examine the movement as a whole. See that the wheels and the barrel are upright within the frame ; that the wheels are free of each other, and of the frame or any part connected with it ; that the chain is free of the pillar and the stop-stud ; that the dial feet are not in the way ; and that the dial, or brass edge, as the case may be, fits properly against the pillar plate. By laying the nail on the surface of the glass, it will be easy to see whether there is sufficient freedom between the socket of the hand and the glass. In case of doubt, place a small piece of paper on the hand, close the bezel, and tap the glass with the finger while the watch is in an inclined position : if free, the paper will be displaced. The dome must be at a sufficient distance from all parts of the movement, more especially the balance cock. If there is any occasion for doubt on this point, put a thin layer of rouge on the parts that are most prominent. Close the case, and, holding it in one hand to the ear, apply a pressure at all parts of the back with a finger of the other hand, listening attentively in order to ascertain whether the vibrations are interfered with. If the interval is insufficient, a trace of rouge will be found on the inside of the dome. In such a case, if the dome cannot be raised nor hollowed slightly in the mandril (when formed of metal), lower as far as possible the index work and the balance-cock wing, and fix in the plate, close to the balance, one or two screws with mushroom heads that will serve to raise the dome.

Verge Watch. — To take the movement to pieces, begin by detaching the hands with a pair of nippers (if it is carefully done, the hands will not be marked), then draw out the pins which hold the dial, and remove it. These pins are sometimes very troublesome to get out with the nippers or pliers, and are often best removed by pressing the edge of a knife into them close to the dial feet, and using the blade as a lever. The mainspring must now be "let down." Unscrew the click screw a little, place a fitting watch-key upon the barrel-arbor square, relieve the ratchet, and gradually let the spring down. Beginners should always make it a rule to let down the mainspring at the commencement, and if the watch has maintaining power, as most lever watches have, also to relieve the detent, for it is a very bad plan to let the train "run" down, and if by any chance the top plate is removed with the spring wound up, the effect would be probably most disastrous. The motion work, including the cannon pinion, being removed and the spring let down, proceed to unturn the cock screw, and take off the cock. The cock is the piece that receives the top pivot of the verge, staff, or cylinder. See that none of the screws overturn ; it is important that all screws should be perfect in this respect. If any should overturn, make a note in pencil on the board paper so that it will not be forgotten.

Withdraw the pin that secures the balance spring to the stud, turn round the balance until the spring is free of the stud, and remove the balance. In some watches, the curb pins will be found bent over to prevent the balance spring from escaping from between, or more than one coil getting in. In such cases, the balance spring must be freed from the curb pins as well as the stud before attempting to remove the balance. Proceed to take off the name-plate and regulator slide, push out the pillar pins, and remove the top plate, when the wheels may be removed from their positions, and the watch will then be "taken to pieces."

Clean the various parts before proceeding with the examination. Before beginning to brush, the oil and dirt must be wiped off the plates with a small piece of clean chamois leather. The wheels and pinions must be well brushed, and the leaves of the pinions thoroughly cleaned with a pointed piece of pegwood. A small piece of elder pith will be best adapted for cleaning the pivots.

When the dirt and oil are removed from every piece, and the pivot holes in the plates have been "pegged out," until the pegwood comes out quite clean, the movement is ready for further examination. See that the pillars are all tight in the frame, likewise the studs that secure the "brass-edge" to the frame when the dial is not pinned on direct. If either of the pillars is loose, pin on the top plate with 4 examining pins; then rest the end of the pillar to be tightened upon a filing block, and carefully rivet the pillar till it is quite firm. In a similar manner, the brass-edge pillars or studs may be tightened, removing the dial and pinning on the brass-edge to the pillar plate. If either of the pin holes is broken out, or the end of the pillar is broken off, it may be repaired in 2 ways. File off the broken end of the pillar till a little lower than the surface of the top plate, make a centre mark, and drill a deep hole with the largest drill it will safely bear; then solder in a piece of brass wire to form a new pillar end, in which the pin hole may be drilled. The other way is to use a smaller drill, and fit a screw in. Proceed to try if all the wheels are tight on their pinions. Hold the pinion firmly between the smooth jaws of an old pair of pliers (or preferably a brass or copper lined pair), and see that the wheel has no movement either backwards and forwards, or up and down. If a wheel is found to be loose, it must be secured at once. Place the arbor in one of the holes of a pinion stake, so that the pinion head rests firmly upon it, and, with a half-round punch and hammer, carefully rivet the pinion until the wheel is tight and runs true in flat.

Such wheels as are mounted upon brass collets, like the contrate wheel in the verge movement, and the escape wheel in the lever, require to be treated rather differently. The collet must rest firmly upon the jaws of a "pair of clams," the clams being held in the vice; then the brass rivet is slightly burred over. In the case of a lever escape-wheel, great care must be exercised, or the wheel will be found out of flat, and it will not admit of being made true by the ordinary method of "bumping." The best method of making it secure is to carefully fix the pinion arbor in the clams, and then use the sharp point of a needle as a punch, making 2 or 3 burrs on the rivet of the collet. By this means, the wheel is rarely thrown out of flat. Ordinary flat wheels are riveted as nearly true in flat as possible, and then if necessary, "bumped"—that is, the wheel is set up between the ends of a pair of callipers, and by means of a little strip of brass—called a "toucher"—the crossings are found, which require bending to make the wheel run flat. It is then laid across the end of a bumping-up stake, and the necessary crossings are gently tapped with the hammer until the wheel runs true. The wheels must further be examined to see if any of the crossings are broken, or any of the teeth broken off or bent. If either of the crossings is broken, there is no good remedy but a new wheel; although sometimes, when the watch is an inferior article or old the crossing may be neatly soldered. In a good watch, such a thing should not be countenanced. If a tooth is bent, it may frequently be raised to its proper position by the blade of a penknife, and sometimes by means of the tweezers.

To replace a broken tooth, a new tooth can be put in; it is never advisable to put in more than one tooth at the same part of the wheel. A wheel having 3 or 4 teeth broken off consecutively should be discarded as quite unfit for service, and replaced by a new one. If any of the pivots shows signs of wear, is rusty, or in any way rough or uneven, it must be carefully burnished till quite smooth and straight, and the ends properly rounded up. When all these points are attended to, put the centre wheel in its place in the frame, pin on the top plate with the examining pins, and see if the centre wheel runs flat with the pillar plate, or, in other words, that the pinion is upright. If it is not upright, rest the edge of the pillar plate on the workboard, and hold a small filing block upon the edge of the top plate in such a position that a few smart taps with the hammer will put the frame in its proper position. This being done, the depths, end-shakes, and pivot holes claim attention. First, try the great-wheel depth with the centre pinion, observing particularly at the same time that the fusee stands quite upright in the frame, for if it leans at all towards the barrel, most likely the chain will not run on properly, but slip up the fusee. See that the pivot holes are of the right size, and the end-shakes correct; if not, alter as may be necessary. Try, in the same manner, the centre-wheel depth with the third pinion, the third-wheel depth with the fourth pinion, and the fourth-wheel depth with the escape pinion, taking care to remember the pivot holes and end-shakes. Observe, also, that the centre wheel is free of its bed and the third wheel of the pillar plate.

In verge watches, it is very essential that the mainspring should be adjusted to the fusee, for the vertical escapement is so sensitive to variations of the motive force, that the time indicated would vary with the force that reached the escapement. In other escapements there is a kind of compensation in the action of the escapement which renders adjustment unnecessary. To adjust the mainspring, the barrel, fusee, and centre wheel are placed within the frame, and the top plate is pinned on. The chain is then attached to the fusee by the small hook, and to the barrel by the large hook, and wound up tight round the latter by turning the barrel arbor with a bench key. The ratchet is placed on the barrel arbor, and the spring is "set up" about half a turn—that is, the arbor is turned round about half a turn more than is required to pull the chain tight. The "adjusting-rod" (which is merely a weighted lever with sliding weight) is then secured to the winding square, and about one turn is given to the fusee. The weight is then moved along the rod, until it exactly counterbalances the force of the spring. The fusee is then turned till filled with the chain, and tested to see if the mainspring exerts the same power at the last turn as it did at the first. If the last turn will pull over the weight quicker than the first, the spring is not set up enough. If, however, it shows less power at the last turn than at the first, then it is set up too much. When the correct adjustment is found, a slight mark is made upon the end of the top pivot of the barrel arbor, and a corresponding one on the name plate or top plate, as the case may be. Another item requiring attention is to see that the cannon pinion does not confine the shake of the centre wheel, and also that the cannon-pinion teeth are free of the third-wheel teeth.

Having completed the examination of the watch, with the exception of the escapement—which for the present is assumed to be correct—it only remains to clean the different parts and put them together again. The greatest care must be taken to thoroughly clean each piece, and keep it clean until the movement is replaced in the case. Several methods are followed for giving the work a good appearance. Some workmen dip the various parts into pure benzine, others into spirits of wine or some other liquid, which renders the removal of grease and dirt easy; but equally good results will be obtained from the following plan: Use a good soft watch-brush, occasionally rubbing it gently upon a piece of prepared chalk or burnt bone, holding the wheels, plates, and other parts in a piece of clean tissue paper, to prevent the perspiration from the skin soiling them. As each piece is cleaned, it must be placed under a "covering glass" (a wineglass broken at the stem being generally used for the purpose), to keep it free from dust until the movement is put together again. The chain does not require brushing, but simply wiping with a clean piece of chamois leather or tissue paper. The "balance spring" (usually known as the hair spring) is best cleaned by laying it flat on the board paper and gently patting it with the brush; when very dirty or oily, the quickest way is to place it in some spirits of wine for a few minutes, and then pat with the brush.

The parts being ready for putting together, the first item to attend to is the oiling of the pivots which cannot be reached with the oiler after the movement is together. In the verge movement, these are the foot hole of the potence, the dove-tail hole, follower hole, the pivots of the barrel arbor on which the barrel turns, and the jewel holes in the frame which have end-stones or cover-pieces in the lever.

The plan of putting together is as follows: Take the potence, and, having oiled the foot and dove-tail holes, screw it in its place upon the top plate, put in the escape wheel (called the "balance wheel" in the verge escapement *only*), push in the follower, and oil its hole. Care must be taken to apply only a very minute quantity of oil—too much oil is as bad as none at all. See that the end-shake of the balance-wheel pinion is only just sufficient to ensure freedom, and that the wheel turns freely. Next take the pillar plate and arrange the wheels in their proper places in the following order: third wheel, centre wheel, fusee, barrel, and lastly the contrate, or fourth wheel. Put the top plate in position, and carefully guide the pivots into their respective holes, keeping the plate just tight down upon the pivots, but using no undue force. When all are in their right places, secure the top plate with the examining pins, and see that the train of wheels runs freely. In putting together, every piece must be held either in tissue paper or the tweezers, and no "finger marks" must appear on the plates or elsewhere. If the wheels all turn freely, the examining pins may be withdrawn one at a time, and replaced with nicely-fitting burnished pins of suitable length.

Adjust the name plate, as well as the slide containing the index, or regulator, and secure them with the screws. Try all the end-shakes, and see that each piece has the necessary amount of freedom without excess. Attach the chain by the small round-ended hook to the fusee, and by the large pointed hook to the barrel, and wind it regularly round the latter till the chain is pulled tight. Then set up the spring in accordance with the adjustment previously made. The pivot holes of the frame may now be sparingly oiled also the hole in the cock which receives the top pivot of the verge. Proceed to put the verge in, exercising great care, for owing to its very fragile construction it is easily broken. Always see that the bottom pivot of the verge is fairly in the foot hole before attempting to put the cock on in place.

The arbor that carries the balance, whether it is called a verge, a cylinder, or a staff, has to be placed in a certain arbitrary position relative to the next piece which moves it, in order to ensure the correct action of the escapement. When it occupies this position, it is said to be "in beat"; when otherwise, "out of beat." This position is necessarily determined by the connection of the balance spring with the plate, and one of the functions of the balance spring is to continually restore the balance, and with it the arbor, to its neutral position. The operation of finding the exact place for the balance spring to be secured in the stud by means of a pin is called "setting the watch in beat"; a practical method of setting the verge watch in beat is as follows: Put the end of the hair spring through the stud, so as to bring the verge approximately to its correct position, and pin it moderately tight, taking the precaution to have the spring within the curb pins and quite flat. Put on the cock, and turn in the screw. Hold the movement in the left hand, and with the thumb of the right hand slowly and carefully press forward the contrate wheel, allowing each escape of a tooth to be quite distinct; observe how much the balance is drawn to the right in order to allow the escape to take place, and how much to the left. If it is found that the distances are equal, the watch is in beat; if unequal, the cock must be removed, the pin withdrawn a little, and the balance spring moved in the the direction necessary to make the "draw" equal.

This being correct, the pin must be pressed in tight, the balance spring set quite flat, working equally between the curb pins, and finally the cock screwed firmly on. The chain can now be wound upon the fusee, guiding it carefully into the grooves by means of a pointed peg;—the stopwork having been tested at the time of adjusting the mainspring. Put on the cannon pinion, minute wheel, and hour wheel, and pin on the dial. The movement will now be finished and ready for the case.

Geneva Watch.—The following remarks refer in the main to foreign watches with a Lepine movement.

Rotate the wheels connecting the hour and minute hands by the aid of a key; a glance will suffice to show whether the several depths, which should be light, are satisfactory. The wheels should not rub against one another, the plate, barrel, or stopwork. The barrel should have been previously examined to ascertain that it was not inclined to one side, as, if it were, an error would probably be made in estimating the degree of freedom. The set-hands arbor (the square of which should be a trifle smaller than that of the barrel arbor) must turn rather stiffly in the centre pinion, and the cannon pinion must be held on the arbor sufficiently tight to avoid all chance of its rising and becoming loose; for this would alter the play of the hands and motion work. Any fault found in the adjustment should be corrected at once, to avoid doing so after the movement has been cleaned. Slightly round the lower end of the cannon pinion and the steel shield, taking care to avoid forming a burr on the pinion leaves. These two pieces ought to rest on the ends of the centre-pinion pivots, and at the same time be some distance removed from the plate and bar respectively.

There must be sufficient clearance between the plate and barrel; the barrel and centre wheel; the several wheels in succession, both between themselves, their cocks, and sinks; between the balance on the one hand and its cock, the centre wheel, the fourth-wheel cock, the balance-spring-coils and stud on the other. The fourth wheel is frequently found to pass too near to the jewel forming the lower pivot-hole of the escape wheel. End-shake of the wheels may be tested by taking hold of an arm of each with tweezers and lifting it. This may also be done in the case of the escape wheel, but, when the cock is slight, it will be sufficient to press gently upon it with a pegwood stick, then releasing it and observing the apparent increase in the length of pivot. At the same time ascertain that the width and height of the passage in the cock are enough to allow the teeth, when carrying oil, to pass with the requisite freedom. Holding the watch on a level with the eye, lightly raise the balance with a pegwood point several times, each time allowing it to fall. The variation observed in the space between the collet and cock will indicate the end-shake of the balance staff.

Side play of the balance pivots in their holes can be easily estimated by touch, or by the eye, attentively watching the upper pivot through the endstone with a powerful glass, while the watch lies flat, and the lower pivot in the same manner with the watch inverted. If the endstones are not clear enough, which is rare, first remove one endstone, and examine the pivot; then replace it, and remove the other. It should be possible to rotate the balance until the banking pin comes against its stop, without causing the escape wheel to recoil at all, or allowing a tooth to catch outside the cylinder behind the small lip. The banking pin sometimes passes too near to the fourth-wheel staff. The U-arms should rest as nearly as possible in the middle of the banking slot of the cylinder; that is to say, they should be as far from the upper as from the under edge of this slot, so that the end-shakes may have free play in all positions of the watch. See that the balance spring is flat; that it coils and uncoils regularly without constraint; that it does not touch the centre wheel, the stud, or the inner curb-pin (with its second coil).

The rapid examination of the escapement may now be regarded as complete, if the watch in hand is merely being cleaned after having previously gone well. But if a watch that has not gone well previously, or if a new one, the action of the escapement must be thoroughly tested.

The train being in motion through the force of the mainspring or the pressure of a finger against the barrel teeth, examine with a glass all the depths that are visible. That of the escapement, for example, can be easily seen through the jewelled pivot-hole when this is flat, the watch being laid horizontal and a powerful glass used. When the action cannot be seen in this manner with sufficient distinctness, hold the watch up against the light and look through it. Depths that cannot be clearly seen, or about which any doubt exists, must be subsequently verified by touch. With a new watch, it may be found necessary to form inclined notches at the edge of the cocks or near the centre hole of the plate, so as to see the action of the depths. But it is important that the settings of the jewels are not disturbed, and indeed that enough metal is left round these holes to admit of their being re-bushed, if necessary.

Invisible and doubtful depths must be tested by touch, and the requisite corrections applied after having repolished the pivots, etc., as may be necessary. Holes a trifle large are less inconvenient than those which afford too little play, providing the depths are in good condition.

Remove the endstone from the chariot, and see that the pivot projects enough beyond the pivot hole when the plate is inverted. Remove the cock and detach it from the balance. Take off the balance spring with its collet from this latter, and place it on the cock inverted, so as to see whether the collet is central, when the outer coil is midway between the curb pins. Remove the cock endstone and endstone cap, place the top balance pivot in its hole, and see that it projects a little beyond the pivot hole. Put the balance into the "figure 8" calliper to test its truth, and, at the same time, to see that it is sufficiently in poise; remember, however, that the balance is sometimes put out of poise intentionally.

Let the train run down: if it does so noisily or by jerks, it may be assumed that some of the depths are bad, in consequence of the teeth being badly formed, the holes too large, etc. To test the latter point, cause the wheels to revolve alternately in opposite directions by applying the finger to the barrel or centre-wheel teeth, at the same time noting the movement of each pivot in turn in its hole; a little practice, comparing several watches together, will soon enable the workman to judge whether the play is correct. The running down of the train will also indicate whether any pivots are bent.

Remove the barrel bar with its several attachments; also the third wheel, and, if necessary, test the unrighting of the centre wheel by passing a round broach or taper arbor through it, and setting the plate in rotation about this axis, holding a card near the edge while doing so. This will indicate at once whether the axis of the wheel is at right angles to the plate. If a marked deviation is detected, or the holes are found to be too large, they must be re-bushed and uprighted. If the error is but slight, the axes may be set vertical by bending the steady-pins a little, in doing which proceed as follows: Set the bar in its place alone, the screws a little unscrewed; rest the side of the bar opposite to that towards which it is to be bent against a piece of brass held in the vice, and strike the farther edge of the plate one or two sharp blows with a small wooden mallet. Experience alone can teach the workman to proportion the blow so as to obtain a given amount of deviation, and must enable him to ascertain whether it is desirable or not to pass a broach through the steady-pin holes before operating as above explained.

The centre pivots must project beyond the holes in the plate and bar. A circular recess is turned round the outer end of each of these holes so as to form reservoirs for oil. Owing to the neglect of these simple precautions, many watches, especially those that are thin, come back for repair with their centre pivots in a bad state, because the oil could not be applied in sufficient quantity, and has been drawn away by the cannon pinion or the steel shield. If a watch has a seconds hand, ascertain by means of the calliper that its wheel is upright. Finally, examine each jewel to see that it is neither cracked nor rough at the edges of the hole.

The side spring, which must not be too strong, should reach with certainty to the bottom of the spaces between the teeth of the ratchet, and this latter should be held steadily in position by the cap. The barrel is made straight and true on its axis, the arbor having been previously put in order if required. It is a good plan after making the extensive repairs here spoken of to again test the barrel and centre-pinion depth, either by touch or by drilling a hole for observation. The screw of the star wheel must not project within the cover nor rub against the dial; it must be reduced, if either case presents itself.

The action of the stopwork must be well assured, especially when the actual stop occurs. It is a good plan to, as it were, "round up" the star wheel and finger-piece, with an emery stick, supporting them on arbors. There must be no possibility of friction between the finger and the bottom of its sink. To test the stopwork, take up the winding square of an arbor, with the barrel, etc., in position, in a pair of sliding tongs or a Birch's key; hold the tongs between the last three fingers and the palm of the left hand, the first finger and thumb being applied to the circumference of the barrel so as to rotate it, first in one direction and then in the other. During this movement, take a pegwood point in the right hand, and try to turn the star wheel *against* the direction in which it would be impelled by the finger. The tooth that is just going to engage with the finger will thus be caused to take up the worst possible position for being turned, and thus, if the action proves to be satisfactory for each tooth, you may rest content as to the future; providing, of course, that the engagement takes place square, and there is no tendency to cause distortion of the metal. By holding the sliding tongs in a vice, both hands can be kept at liberty.

Cleaning.—It facilitates the work to secure order in taking to pieces and cleaning, preventing the screws from being mixed, etc. It is a good practice to prepare beforehand one or more boards, in which grooves and holes are made in positions to correspond with those of the several pieces on the plate of the watch, as indicated by Fig. 110. The round holes receive the cock and bar screws, which may be cleaned while the other parts are in the benzine solution. (Two holes are shown side by side for each bar and cock, so that the same plate will serve for a large and small watch.) The oval or circular hollows at *a* and round *b* receive the cap screws, and *b* the shield; *c* holds the screws of the side spring and star wheel, and the finger-piece pin; *d* is for the screws of the top endstone, and *e* for those of the bottom endstone, etc.

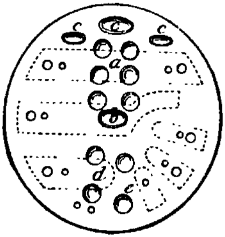

FIG. 110.

Very conveniently divided deal boxes, for holding the several parts of a watch when taken to pieces, are in general use by watchmakers. They are of foreign manufacture, and measure about 6 in. by 4, and 1 in. in depth, thus being large enough to contain all the parts of any ordinary watch. Every young workman will find the advantage of noting on a paper, bearing the number of the watch, the successive operations that have to be done, striking them out one by one as the work progresses.

Whatever the system of cleaning adopted, it is essential that it be concluded by passing a pegwood point into each of the holes. Brilliancy is given to the surfaces of cleaned pieces by passing a carefully kept fine brush over them. A brush that is greasy can only be cleaned by soap and water, and a new brush is prepared for use by passing an inclined cutting edge over the ends of its bristles so as to taper them off to fine points, and to remove knots due to hard parts or to bristles becoming united. This preliminary treatment is completed by charging the brush with French chalk, and rubbing it vigorously on a dry crust of bread, until the brush can be passed over a gilded surface without scratching it. The bristles are maintained in good condition by the same treatment. Billiard chalk is very effective for this purpose. The greater number of cavities there are in a crust the better it will act. Groat bread seems to be preferable to that made from wheat, because the latter contains greasy particles which prevent the brush from being kept thoroughly clean. A burnt bone is an excellent substitute for the crust, and has the advantage of causing the brush to impart a very brilliant appearance to objects on which it is used.

Cleaning with a brush is less used now than formerly, as it can be adopted with safety with the old-fashioned gilding, but is too severe for the thin galvanic coats that are applied at the present day. It may, however, be resorted to for getting up the surface of polished brass wheels, for example. Put some French chalk or powdered hartshorn (which can be bought at a chemist's) in pure alcohol. Shake the mixture, and with a fine paint-brush coat the object with a small quantity of it, subsequently brushing the surface with a brush that is in very good condition. Polished wheels may be made to present a very brilliant appearance by this means, but their teeth and the leaves of pinions must be afterwards carefully cleaned. The French chalk and hartshorn are more effective according as they have remained a longer time in the alcohol; doubtless owing to the fact that the hard grains are then more completely dissolved.

In soaping, it is advisable to use a soap that quickly produces a good lather. The object is held in the hand and cleaned by rubbing with a soft brush charged with this lather; then immerse first in clean water, and subsequently in alcohol, moving it about in each; it may be left for a few seconds in this latter, and, on being removed, it is dried with a fine linen rag or soft muslin. A stroke with a soft brush in good condition will give brilliancy to the surface. If cold water dissolves the soap very slowly, employ warm. If about to soap polished wheels, the surface must be first got up with a buffstick and rouge, or by brushing with hartshorn. The balance spring may be cleaned by laying it on a linen rag doubled, and tapping it gently with a brush charged with lather; then dipping in water and alcohol in succession. The alcohol may be used hot or cold, its action being more rapid and effective in the former case. But there is no occasion to use hot alcohol except when dealing with substances such as wax, that resist its action.

The employment of essences in cleaning watches is becoming more general every day. They are to be obtained at all the tool-shops, together with full instructions in regard to their use. A few observations may be not out of place. The objects are left in the solution for a few minutes, in order to allow all adhering matter to dissolve, but not too long, as certain qualities of benzine, etc., are apt to leave stains. Dry the pieces on removing them, and finish by passing over a fine brush that has been charged with chalk and subsequently rubbed on a hard crust or burnt bone. The following composition has been strongly recommended: 90 parts by weight of refined petroleum, and 25 of sulphuric ether. The objects are immersed for several minutes, and on removal from the bath are found to be clean and bright. It must not be forgotten that many of these essences are liable to ignite near a lamp.

Putting together.—The following 3 rules must be observed in arranging a system of putting the watch together: (1) avoid taking up the same piece 2 or more times; (2) hold it lightly as any pressure will produce a mark; (3) keep it as short a time as possible in the fingers. Any linen rags used must be free from fluff, but rags of all kinds should as far as possible be replaced by certain kinds of tissue paper. The best kind will be that which, while securing a given degree of pliability, will prevent heat and moisture from passing through. Blue tissue paper should be avoided, as it is often found to encourage the formation of rust on steel-work.

The following order is often adopted in putting together the ordinary form of Geneva watch. Commence by putting the several parts of the barrel together, attaching it to the bar and observing the directions given farther on with regard to the distribution of oil. Owing to the position of the stop-finger, it is sometimes found that the mainspring must be set up either ½ or ¾ of a turn. Very often ½ is not sufficient, and in such cases it is necessary, before putting together, to ascertain that the spring admits of at least 5 or 5½ turns in the barrel. If it will not allow this amount, and yet has to be set up ¾ of a turn, too great a strain will come upon the eye of the spring in winding. Fix the chariot with its endstone on the under side of the plate. Replace the fourth wheel, making sure that it is free, has no more than the requisite end-shake, and is upright. Then the escape wheel, testing it in a similar manner. See that the teeth have sufficient freedom on both sides of the cock passage, then make the 2 wheels run together with a pair of tweezers or pegwood in all positions of the plate to make sure of everything being free.

Having attached the index and endstone to the balance cock, and the balance spring to the balance (observing that the centre of the stud is against the dot on the balance rim), place some oil in both the balance pivot-holes; adjust the balance to the cock, after placing a drop of oil in the cylinder, and set in position on the plate. Some workmen apply a drop of oil to the top of the escape-wheel pivot-hole before setting the balance cock in its place, but others prefer only to add the oil after the escapement has been tested. Placing a small piece of paper first between the balance and cock, and then between the balance and plate, ascertain whether the escape wheel occupies its correct position in reference to the cylinder, in order that the escapement may act properly. This test is especially necessary in dealing with very thin watches or those in which the cylinder banking slot is exceptionally narrow.

Next fix the barrel bar to the plate. Set the third wheel in its place, and lastly the centre wheel, after putting a little oil on the shoulder of its bottom pivot. Before putting the bar over it, apply oil to the top pivot in a similar manner; then screw it down. After this is done, screw on the third-wheel cock. Apply a small quantity of oil to the 2 centre pivots, and very lightly to the others that have not already been oiled; give a turn to the key, and listen to the tick of the watch in all positions. This should always be done before replacing it in the case. After passing the slightly-oiled set-hands arbor through the centre pinion, and adapting the cannon pinion to its end, reverse the watch, passing the end of the centre arbor through a hole in the riveting stake, so that the watch is supported on the end of the cannon pinion; a light blow of the hammer on the square end of this arbor will then suffice to drive the cannon pinion home. Some do this before replacing the movement in its case, and some after. Add a little oil to such pivots as have not already received enough, and fix in their places the remaining parts of the motion work, the dial and hands: the watch then only requires to be timed.

Oiling.—The distribution and application of the oil are of more importance than might be thought, and have a very marked influence on both the time of going and the rate. Very fluid oil may be used for the escapement and fine pivots, where only a small quantity is needed, and the pressure is slight; but it is not suitable in other places, on account of its tendency to spread, and leave the rubbing surfaces. If too much oil is applied, the effect is the same as if there had been too little; it runs away, and only a minute quantity is left where it is wanted.

To apply oil to the coils of the spring is not enough; some must also be placed on the bottom of the barrel. Before putting on the cover, moisten the shoulder of the arbor-nut that comes in contact with it with oil; by doing so, when oil is applied to the pivot, after the cover is in its place, this oil will be retained at the centre of the boss in the cover. Moreover, it will not then be drawn away by the finger-piece, passing from this to the star wheel. The oil applied to the upper surface of the ratchet, to reduce its friction against the cap, must not be in such quantity as to spread on to the winding square. It is a good plan to round off the lower corner of this cover. The observation made in reference to the oil applied to the barrel cover may be repeated for the centre wheel.

After the drop of oil is introduced into the oil-cup of the balance pivot-hole, insert a very fine pegwood point, so as to cause the descent of the oil; a small additional quantity may then be applied. When this precaution is not taken, it frequently happens that in inserting the balance pivot, its conical shoulder draws away some of the oil, and there is a deficiency both in the hole and on the endstone. Some workmen place a single drop of oil within the cylinder, and when the escape wheel advances, each tooth takes come up. This method is unsatisfactory, because the earlier teeth receive such a quantity of oil that it runs down the pillars, where it is useless, and merely tends to increase the weight of the wheel. A much better plan is to put a very small quantity in the cylinder, and on the flat of each tooth, or every second or third tooth. It will thus be evenly distributed, and will not tend to flow away. The escape-wheel pivots require but a small quantity of oil. It often happens, however, that the workman applies too much, and it runs down to the pinion. The leaves thus become greasy and stick, while the pivots are running dry.

English Watch.—Many of the remarks made in speaking of the Geneva movement are equally applicable to that of English construction. It will be well, however, to supplement them by a few special directions. The following points require attention. See that the position of dial is not altered by closing down the bezel; that the fusee dust-cap does not touch the dome or cap; and that the diamond endstone or other jewelling of the balance cock is free of the case. In ¾-plate watches the chain is occasionally found to rub against the edge of the case, or the top plate to press against the bottom edge of the same, causing the train to bind. See that the balance and chain, and the fusee great wheel, are free of the cap where one exists: the chain is especially liable to rub after the breaking of a strong spring, which may cause the barrel to bulge, when it may also rub against the potence. Ascertain that none of the dial-plate feet or pins touch the train; that the hour wheel is clear of the third and fourth wheel bar; and the minute wheel out of contact with the dial plate, and not pressed by the dial. See that the third wheel is free in its hollow; and that the balance, more especially in oversprung watches, is clear of the barrel.

The index or regulator must be tested, especially in watches that are undersprung, at several points between "fast" and "slow," to see that it nowhere approaches too near the spring, is held with sufficient firmness, and that it never comes near enough to the guard pin for contact to occur. See that the potence screw and steady-pins do not project, and that the barrel does not touch the name plate, balance cock, top plate hollowing or great wheel. Before taking off the top plate, notice the position of the detent in the steel wheel, and the amount of its endshake; the wear of the holes, and freedom of the train wheels; the position of the third pinion with respect to the centre wheel, and that of the escape wheel to the lever. See that the banking pins are not loose or bent; that the guard pin, which protects the balance staff when the chain breaks, is near enough to the barrel and the potence. When the watch is taken to pieces, any loose pillars or joints must be secured, pivots examined to see whether worn or bent, and those working on endstones, that they come through the holes. The fourth-wheel pinion must be free in the hollow of the pillar plate and the centre wheel in its hollow; a similar examination also must be made of the collet and pin which secure the great wheel to the fusee. If a chain is broken near the barrel end, the stopwork is probably defective or the spring too strong.

The following faults may occur in English stopwork. The stop may come opposite the fusee snail too soon or too late, allowing one turn too few or too many of the fusee; or the back of the snail may butt against the stop, and thus stop the watch after going for a few hours. Overwinding sometimes occurs in consequence of the stop spring being locked between the shoulder of the stop and its brass stud; and the blade of the snail or the end of the stop may be worn or bent in cleaning. In ¾-plate fusee watches, see that the balance does not come too near to the fusee, fourth wheel, centre wheel, and sometimes the escape wheel. The breaking of a mainspring sometimes strains certain teeth of the great wheel.

In examining a lever escapement, the following particulars should always be attended to. See that ruby pin and pallet stones are firmly set; that neither pallet nor roller is loose on its staff; and that the lever and pallets are rigidly fixed together. The guard pin must be firm, the balance well riveted to its collet, the spring collet sufficiently tight, and the curb pins firm. If there is a compensation balance, ascertain that each screw is tight.

So great a variety of arrangements of the mechanism for winding watches at the pendant is met with at the present day, that it would be impossible to give detailed directions in regard to their examination; the following general remarks, however, will be found of value in directing attention to the points which most require it, and will suffice for any intelligent workman. It should be observed at the outset, that the adjustment of keyless work is almost entirely a question of depths, and the workman who has thoroughly mastered this subject will rarely experience any difficulty in dealing with keyless mechanism. Carefully observe each depth, etc., in succession, to make sure that no prejudicial friction occurs either between teeth or by contiguous parts coming in contact. All springs should act solely in the direction in which pressure is required of them.

Special attention should be given to the intermediate steel wheel for communicating motion to the cannon pinion, when this exists, as it is permanently in gear with the train, so that any unevenness of the depth will affect the rate: if the minute wheel have too much end-shake or play on its stud, it is apt to ride on the intermediate steel wheel. The friction of the cannon pinion on the set-hands arbor must not be excessive, since it would involve too great a strain on the teeth of the minute wheel; nor too slight, since the hands would be liable to be displaced on releasing the set-hands stud. If the intermediate wheel has too much end-shake, limit this by an excentric screw overlapping its edge. Test the spring of the set-hands stud, to see that it is not too strong or too weak, and that it moves parallel with the plate. Failure in this latter particular might lead to its rising on to the rocking bar or other piece on which it acts.

Examine the winding-pinion depth, to see that it is neither too deep nor shallow. The set-hands stud spring must be strong enough to resist any accidental pressure on the stud; but, on the other hand, the strength must not be excessive, as the spring will then be all the more liable to break, besides causing inconvenience when setting the hands. The course of the spring should be banked at the point which gives a good depth between the winding and intermediate wheels. The minute-wheel stud must be firm in the plate, as any accidental binding might otherwise unscrew it, occasioning the breakage of the dial. When the minute hand is carried by the set-hands arbor, and not by the cannon pinion, care is necessary in fitting this latter, for if too loose, it will rotate in setting the hands without carrying the minute hand round, and the minute and hour hand will cease to agree.

Attention must be paid to the application of oil to keyless work, as, in its absence, rust rapidly forms, and the mechanism becomes bound. Of course, all bearing surfaces, such as the interior of the pendant, intermediate and minute wheel studs, studs or screws of the rocking bar or other surfaces on which wheels rotate, must be lubricated; an equally important point is to liberally oil the teeth of the winding pinion and the bevel or crown wheel that engages with it. The application of a little oil inside and outside the cannon pinion must not be omitted.

Several watchmakers have noticed that the oil is preserved intact longer after washing with soap, if well done, than after cleaning with benzines, etc., though in some instances it may be that the latter process was not properly performed. However, the following is the method adopted for some years by Bertrand: Dissolve in about 1 qt. of rainwater a piece of Marseilles soap, about 1½ in. square, pared very fine, and add a piece of black soap the size of a hazel-nut. Boil, filter through a linen rag, and bottle the liquid. When required for use, pour a little into a capsule, and place the parts (excepting those fixed with lac) in it, boil it slightly, and after having put back the liquid in the bottle, pass the parts through rainwater, slightly boiling, and then plunge them in alcohol. On taking them out, dry them with a linen rag. By this means, the pieces are much better cleaned than they would be, if benzines were used. Should the polished wheels turn a little brown, the colour may easily be made to disappear by passing lightly over the stained portion, and without touching the steel, a pencil-brush dipped in water mixed with potash oxalate (commonly called salts of sorrel), and dipping in water and alcohol. If necessary, it may be touched up with a dry chamois leather.

Pivoting.—This may, in some respects, be called the most tedious of any work connected with watch repairing; for it is certainly no easy job for the novice to drill down the *centre* of a small pinion, especially when the pinion is left extra hard, which is often the case. Making the drill to the required shape and hardness is one of the main things to be considered. A needle is the best steel to be obtained for this job. Heat the needle in the flame of a candle to a cherry-red, then hammer it into shape. This must be such a form as will give as much strength as possible; therefore, do not hammer the sides too flat, or the edges will snap off when hard. It must not be too pointed for drilling steel, but will work very well without a point, provided a nice cutting shape is obtained, which is secured by making the end a little larger than the other part, and slightly flattened with the round-faced hammer, then stoning up, so that there is an edge in the centre of the flattened part. If this edge is slightly rounded instead of pointed like a brass drill, it will make the drill cut longer than the pointed shape, as there is more of the cutting surface utilised at one time; therefore there is not the amount of wear on any particular point of action, so it will cut long after a pointed drill has become dulled. To get the drill extra hard, hold it in the candle flame until it becomes a cherry-red, then immerse in quicksilver. Do not get it to a white heat, or the steel will be too brittle, and never cut satisfactorily. A candle is much better than gas for making up drills, as the gas burns the steel, owing to the sharp current of air through the burner. Some use water and some oil to harden the drills, while others use the tallow of the candle. Either will have the desired effect, providing the steel has not been heated too much before putting in—a deep red is quite sufficient.

Suppose the drill is hard enough to cut down the required steel where the pivot is wanted—say a verge third-wheel bottom pivot. After finding the centre, apply plenty of oil to the drill, then drill down until you get about the depth of a pivot's length. Now file the steel a perfect fit to this hole. There is no better steel for the pivot than a needle, brought down to a plum colour. When it is stoned to fit the hole tightly, drive it in with the flat hammer. If it is a good fit, you may now cut it off a little longer than required, run a point on it, put the point into the turns, and see if the pinion runs true. If so, the pivot may soon be finished; but provided you have got the pivot a little out of the centre, you must make the point a little out of the centre of it so that the pinion will run true; then turn it true before you begin with the pivoting file, or you will find the pivot will never find the centre by filing. Great care should be taken in getting the point of the pivot in the proper place before beginning to turn. With care, pivots may be put in, so that the watch will not suffer therefrom. Even if it is a wheel, whose being out of poise does not matter, it will throw the depths unequal, providing the pivot is out of the centre. It is sometimes rather tedious to get the pinion true from the point of pivot as advised, but there had better be a few minutes taken there than to slip the job and then have a bad depth to correct.

In putting in a verge fourth pivot, if it be a seconds pivot, drill the pinion far enough, or, as before, the length of the seconds pivot—this will make a firm job of it. Care must be taken not to break the drill in; but with a properly shaped drill and a steady hand there is not often a break.

Whether verge, lever, or Geneva pivots, they can all be done in the way stated, but of course a Geneva escape-wheel pivot requires more practice than a third-wheel pivot of a verge watch. With this the wheel must be taken off in order to get the ferrule on to run it with. In putting on the wheel again the best tool to use is a pinion riveting tool, as it is then left nice and flat. No watchmaker should be without this tool, as it is so useful for all kinds of riveting where accuracy is required. It will leave the brass perfectly polished where it is used to rivet a balance on.

There are pivots where the drill is not used. Some drill in the turns, others use the mandril, with the wheel shellacked firmly in it, holding the drill on the rest; while others employ the old-fashioned method of holding the wheel in the hand and running the drill in the vice holes. The operator may choose his own method.

Now for a pivot without any drilling —a staff top pivot for instance. Drive out the old staff entirely (the steel part of it), then cut off the steel about half as much as reaches through the brass; stone the end flat, then put it in again as before. This will leave a hole in the top part. Put a piece of properly tempered steel in this hole, solder it in with a small portion of solder, then centre the point so that the body of the staff runs perfectly true; put it in the turns, and turn down to required shape for pivot, finishing off with file and burnisher. This is the best method for a staff top pivot, which can be done without much fatigue. Of course this method cannot be resorted to when it is a solid steel staff, such as the Waltham staffs. In this case the drill has to be used; but when the operator has had plenty of practice with the turns he would be very likely to put in a new staff rather than a pivot. Even in putting in a new staff (English), the steel can be driven out, and another piece put in, saving the trouble of turning the brass. In doing this, care must be taken to get the old brass to run true on the centres before using the graver, or the balance will be out of poise.

We now come to the easiest pivot job, although by some it is thought to be a very delicate and tedious job— the cylinder pivot. Provided the top plug is a good fit, but has the pivot broken, simply drive out the plug a little way (the length of the pivot), and run a new pivot on the same plug; turn it back a little way to give it a good appearance. This may be done complete in 10 minutes; so it is not very serious after a little practice has been had at it. In driving out the plugs, make a steel stake with holes through and chamfered on the top; this will let the plug move while the shell is held firmly on the stake.

New Mainspring.—The barrel cover being removed by the blade of a small watch screwdriver, the arbor is first taken out and then the broken spring. If, without doubt, the broken spring was the original spring, and the watch is of fair quality, it is well to follow the rule generally adopted by the trade, and replace it with another of "the same width and strength." Frequently, however, it happens that the spring is not the original, but one put in by some careless workman either ignorant of what conditions a spring should fulfil, or contented with the nearest spring to the original that he happened to possess. In such a case, the general rule does not apply.

Suppose, by way of example, that you have a broken spring to replace, which evidently is not of the proper width and strength for the barrel it occupied, and consequently not adapted to the watch. The first consideration is its width, which should be as great as the barrel will fairly admit, reaching from the bottom of the barrel to the groove barely, excepting where the barrel cover is hollowed out, when it may reach it fully. If the spring is not wide enough, its working will be irregular; if too wide, then it will bind in the barrel. The next point is the thickness, and it is most important that this should be correct for the watch to perform satisfactorily. If the spring is too thick, the action of the escapement will be hurried and its rate unsteady, and the chain more liable to break; while, if too thin, the escapement will be sluggish, and the watch apt to stop altogether. The strength of the spring should be such that, when of the proper length, hooked in the barrel and wound up, it may cause the barrel to make about ⅜ of a turn more than is required by the length of a chain that occupies the fusee when fully wound. The length of a spring should be such that when wound in the barrel it should occupy about ⅓ of its diameter. Having gauged the width and found the corresponding springs, one of the proper strength will be found as a rule to be a little larger in diameter than the barrel, or one that would almost fill the barrel if it were wound in, so that it is necessary to break off a short piece that the barrel may not be too full. This applies to the springs as bought from the makers, coiled within a wire ring, and is merely given as an approximate guide to selection.

Having selected a spring apparently suitable, it must be shortened as much as is necessary, and "hooked in," when it must be finally tested by holding the barrel tight in the left hand and winding up the spring by means of a pair of sliding tongs attached to the squared end of the barrel-arbor, and observing how many times it causes the barrel to revolve. If it makes an insufficient number of turns, the spring is too thick; if too many, it is too thin. Although this may be stated as a general rule, it is not without exceptions, as, for example, in verge watches it is occasionally expedient to use a somewhat weaker spring than will only make the proper number of turns, owing to an imperfect and unequal balance wheel not admitting of a close and correct escapement. There are 2 methods of hooking in mainsprings: in one, the hook is in the barrel, and the spring only requires a hole in it near the end; in the other, the hook is attached to the spring, a hole being formed in the barrel to receive it. In replacing a spring which only requires a hole in the end, it must be carefully tempered by means of a very small flame, so applied that the spring may be gradually and equally tempered from the end where the hole is to be, which should be rather soft, to about ½ in. of its length. The hole should be square, as being the least liable to constrain the spring, and prevent its proper action in the barrel. It is usual, after making the hole, which is punched with a pair of mainspring nippers, to pass a file lightly across the end of the spring and round off the corners, giving it a neat and workmanlike appearance. When the hook is to be attached to the spring, the latter is tempered in the manner already described, and a small round hole is punched in it. A piece of "hooking-in" wire is then fitted to the hole in the barrel, and placed in the jaws of a pair of sliding tongs in such a manner that a pivot may be filed on it to fit the hole in the spring, and cause the piece of hooking-in wire to form a hook standing at the proper angle to suit the hole in the barrel. The hooking-in wire is then put in the vice, and the mainspring is firmly secured to it by riveting, when the length of the wire is cut off, leaving only sufficient to form the hook. The end of the spring is usually finished like the other, but left pointed instead of round.

New Barrel-hook. — When this is necessary, it is always a good plan to put in one of steel, and not brass, as they frequently are. The hook should be "tapped" in very tight and nicely shaped, not standing up too high in the barrel.

Tightening Barrel-cover.– When a barrel cover is loose, it should be covered over with a piece of thin paper and gently tapped with a round-faced hammer all round the edge, which, if carefully done, will spread the cover a little without marking it.

New Barrel-arbor. — There are 3 kinds of arbor commonly in use—the plain English, the plain Geneva, and the Geneva with solid ratchet. The fitting of a new one of either kind requires to be done very carefully, it being absolutely necessary that the pivots should be accurately fitted, and the end-shakes very exact, for the barrel to run true and give satisfaction. Either of the plain arbors can be made from a piece of ordinary round steel, or an "arbor in the rough" may be obtained from the tool shops. In the former case, it will be necessary to turn the steel somewhat to shape in the lathe; but when bought in the rough, the arbor is quite ready for the more exact turning which is done in "the turns." A screw ferrule is attached to one end of the arbor, and the body or centre part is first turned to the proper width and diameter, the measurement being taken from the old arbor by means of the pinion gauge. The arbor is then turned down and polished until it fits the holes in the barrel just tight, when a round broach passed lightly into the holes will give the necessary freedom.

If an English arbor, the next step will be to turn the top pivot and fit it into the name plate, and afterwards file the square on the other end of the arbor to receive the ratchet. If, however, it is a Geneva arbor, the square for the stopwork finger-piece must be made, and the lower pivot finished first, and the top or winding square (which also receives the ratchet) last. In filing these squares, great care must be taken to make them really squares. The best plan to ensure success is to turn a line where the square is to end, and file them up in the turns between the centres. The ends of the squares and pivots are usually finished in the screw-head tool. The hook to take the mainspring is formed by drilling an oblique hole in the body, and driving in very tight a piece of good tempered steel, which is then filed to shape. In case of a Geneva arbor with solid ratchet, it is necessary to buy the arbor in the rough, and advisable to have that kind which is half finished, for the body is then screwed on and the ratchet polished. It is almost impossible to tap a good thread with the ordinary screw-plates suitable for this purpose; and if an arbor not already screwed by the proper plates must be used, it will be found much better to accurately fit on the body with a plain round hole, and secure it with a good steel pin. This latter kind of arbor is generally found where the barrel is "hanging" on the bottom pivot of the arbor, unsupported.

New Barrel.—When it becomes necessary to put in a new barrel, as it sometimes does, either from the barrel cracking, across where the "hooking" is, or from unskilful treatment having spoilt it, the best plan is to send the arbor and old barrel to the material dealers, and have a new one of the same diameter fitted to the arbor. The new barrel will require very little finishing, and it is much better and cheaper than attempting to make one.

Repairing the Chain.—A very frequent occurrence is the breaking of the chain, and to repair it neatly and strongly only a small amount of application is required. One end of the broken chain must consist of a double, and the other end of a single link. It is easy enough, by means of a sharp penknife, to get the single link, but the double one is sometimes more difficult to obtain. The best plan is to rest that end of the chain at which the double link is required upon the filing block, and, with the thumb-nail of the left hand, keep one end of the pair forming the double link tight together, while with the penknife you gently separate the other, so as to loosen the rivet first from one side and then the other. If the chain is then held in the left hand and the small piece of broken link is firmly grasped with the pliers and a sharp pull given, it will be found that the double link is made and ready to receive the single one. When the ends to be joined are placed in position, they should be secured by a rivet made of chain wire; but in the absence of this, a needle, properly tempered to a blue colour, may be used, taking care not to leave the rivet too long. Also remember that the hooks are placed the right way to hook in the barrel and fusee. When a new chain hook only is required, it will be found much easier to turn the chain than the hook, when the latter happens to lie the wrong way.

Chain running flat or off the Fusee. When a chain runs flat, when working back on to the barrel, or slips up the fusee when winding, it must be carefully examined, and the cause found out. Sometimes it results from the chain being too large; then the only remedy is a new chain. At other times it will be found that the delicate spiral projections on the fusee which separate each turn of the chain from the next have become bruised and perhaps broken in places, so that the safe retention of the chain cannot be relied on. If the damage is very serious, the fusee should be re-cut, but if only trifling, it may be rectified by carefully raising the injured part to its proper position and then placing it in the turns, and allowing a graver of suitable shape held in the right hand to lightly scrape out the grooves as the fusee is slowly turned with the left. When the chain runs off without any apparent cause it may be frequently altered by changing it end for end, or by taking a very little off from the outer lower edge of the chain along its entire length. When all these means fail, by putting in a new hole for the top fusee pivot, so that the fusee inclines away from the barrel, a certain cure will be effected, as this must evidently cause the chain to run in its proper position.

Fitting Hairsprings is frequently a source of much trouble for the novice. First get to know what train the watch has; this, of course, will necessitate your knowing the number of teeth in the fourth wheel and escape pinion; that is, if it is a seconds watch; if not, you will have to know the whole train from centre wheel. Now if we find the watch has to beat 18,000 per hour, we get the hairspring that will be the proper strength to make the balance oscillate 300 per minute, or 5 per second. This is done by fastening the centre of the spring to one of the pivots with a piece of beeswax; but notice that the centre of the spring has been made the *proper size* for the collet before being tried, as a spring with its old centre—as made—will be so that it gives its beats slower than when the centre has been broken out to make it fit; therefore when this is correct, and waxed to one pivot, we take hold of the outer coils of the spring, just where the spring is the proper circumference for this coil to reach the same place as the stud and the curb pins. This will be the proper size, but to get the proper strength, we notice the beats it will make, by placing the other pivots on a watch-glass, holding the tweezers about where it should be pinned in the stud; by giving the balance a slight move we soon see the number of beats it will make in a minute, by counting and watching the seconds hand of the regulating clock. If it is a train which requires 16,200, we then have to get the spring of such a strength that it will make 270 vibrations per minute;

but it is best to count every alternate vibration, making the counting 135 per minute for the 16,200 train. If it goes a little over or under this number move the tweezers a little along the spring till you find the exact place where the number is correct; this is just the place to pin in the stud, and the watch will be to time. With the 16,200 train the watch beats 4½ times per second; but some of the old-fashioned levers and Genevas beat only 4 per second; this, of course, can be counted by taking every *alternate beat* until you get 120 per minute. Those who follow this method will be able to set the spring and return it at once ready timed.

Weakening the Hairspring.—This is effected by grinding the spring down. Remove the spring from the collet, and place it upon a piece of pivot wood cut to fit the centre coil. A piece of soft steel wire, flattened so as to pass freely between the coils, and armed with a little pulverised oil-stone and oil, will serve as your grinder, and with it you may soon reduce the strength of the spring. Your operations will, of course, be confined to the centre coil, for no other part of the spring will rest sufficiently against the wood to enable you to grind it, but this will generally suffice. The effect will be more rapid than one would suppose, therefore you will watch carefully, or you may get the spring too weak before you suspect it. Another and perhaps later process is as follows: Fit the collet, without removing the spring, upon a stick of pivot wood, and having prepared a little diluted nitric acid in a watch-glass, plunge the centre coils into it, keeping the other parts of the spring from contact by holding it in the shape of an inverted hoop skirt with your tweezers. Expose it a few seconds, governing the time of course by the degree of effect desired, and then rinse off, first with clean water, and afterwards with alcohol. Dry in the sun or with tissue paper.

* * *

COAL ECONOMISING POWDER.

THIS powder, when made into a solution with water and sprayed on coal, has the effect of delaying combustion to a sufficient extent that combustion is more perfect, sooty flame, smoke and free carbon (soot) being reduced. It might be made up into packets of ½ lb. each, which, dissolved in 12 gal. of water, is sufficient to treat a ton of coal. Sal-ammoniac 8 lb., nitrate of potash 25 lb., lampblack 2 lb.

CONCRETE.

Materials.—*Cement* should be of the best procurable to ensure good and lasting work in concrete construction, the use of a cheap and probably adulterated and defective material being disastrous, and much more costly in the end; therefore the best English Portland cement should be used.

Aggregates.—(*a*) The following materials are *unsuited* for making good concrete, and their use should be avoided if possible; loamy or argillaceous sand; very fine sand, such as "blown" sand; fine sand; road or ditch sand; impure sand or stone, i.e. that which is covered with scale, slime, humus, or is in a dirty damp condition; sand or stone impregnated with sewage or ammoniacal water; round or nodular grained sand or stone; stone or sand from soft sandstone rock;

sand which is dull, murky or opaque; stone or sand with a surface very smooth or polished; stone or sand that has lime scale or calcareous matter attached to it; pit sand with a few exceptions; soft stone, or sand with soft grains; shell sand, or broken shells.

(*b*) *Aggregates* that make good concrete: stone or sand from quartz rock, and granite chips; stone or sand from hard sandstone or other hard rock; split sea beach stones, if they have not very smooth surfaces; all very hard angular and rough faced stone or sand; sea beach shingle and sand, if not nodular and polished from mechanical attrition; sand from a river whose bed and watershed are rocky—preference being given to that found along the course of the river and not at the mouth; sand with large grains—of equally coarse and rough, use the larger grained sand; sand with coarse or rough grains in the case—of sand of grains of equal size, use the coarser or rougher; sand which is clean, clear and translucent; the hardest stone or sand available; the stone or sand should be angular and fragmentary in form; the surface of the stone or sand should be rugged and coarse; stone broken from pieces of hard rock by a machine, the powder being removed; sand obtained from hard rock crushed by machinery, the dust being removed; sand or stone obtained from rock which is the most durable.

Proportions of Ingredients. — A watertight cement cannot be produced unless the cement which is supposed to set watertight, entirely fills the interstices of the aggregates and encircles them. A satisfactory concrete can only be obtained by the cement being properly apportioned to the sand, and the mortar so formed to the stone, or gravel, or aggregates.

A simple method of ascertaining the quantity of cement required is as follows: shake or ram down the stone or gravel into a watertight box or measure of known volume, filling it completely. Then add as much damp sand as possible, shaking it down among the gravel, gauging the quantity used. Finally pour in as much water as the mixture will contain; the quantity of water gives the net cubical contents of the cement required, a quantity which should be increased by about 10 per cent., to allow for imperfect amalgamation, which cannot be so complete as with water, to allow for any defects in mixing, and to ensure that all the interstices of the sand are filled with cement.

To ascertain the volume of sand required, tightly fill a measure with the stone, and fill up with water; the volume of water required to do so being equivalent to the cubical content of the interstices which should be filled with sand.

It should be noted that in dealing with concrete all measurements are usually given in volumes. A mortar of 2 of sand to 1 of cement is most commonly employed in good work, but for exposed work in deep water a mixture of 1½ of sand to 1 of cement should be employed, as experiments have proved that such a mortar will make a concrete sufficiently impervious to resist pressures of 30 lb. per square in.

It is customary to designate the proportion of the aggregate in multiples of the cement, which is used as the unit of measure. Thus a 1 : 2 : 5 mixture consists of 1 part by volume of cement, 2 parts of sand, and 5 of stone or gravel.

Sizes of Stone or Gravel.—In order to obtain an ideal concrete the materials composing the aggregate should be of varying sizes from the largest stone to the finest sand, such proportions being used as will produce the most compact mass. For reinforced concrete, the broken stone or gravel ought never to exceed a size that will pass a 1¼-in. screen, and when the reinforcement is closely spaced, it ought not to be larger than that which will pass a ½-in. screen; a usual size is that which will pass a ¾-in. screen.

Mixing.—The points to be insisted on to secure a good mixture are (1) Exact measurement of materials; (2) thorough mixing till the colour and consistency of the mass are uniform throughout; (3) the use of the correct quantity of water; (4) the concrete should be mixed as near as possible to the work.

The cement, stone, and sand, should be mixed first until of a uniform colour throughout, and then the water added from a can with a rose spout, the mass being steadily turned over at the same time. When the required amount of water has been added, the concrete should be thoroughly mixed with the shovel.

For further information on this important subject readers are advised to consult the valuable works of Reid on 'Cements and Reinforced Concrete Construction,' and of Gillette and Hill on 'Concrete Construction, Methods, and Cost.'

Concrete Foundations for Roadways.—*See* PAVEMENTS.

Coke Breeze Concrete.—This is largely used for flooring purposes. The coke breeze is obtained from the gasworks (or may be crushed coke), it being the fine coke (which will pass through a ¼-in. mesh sieve, and which is practically unsaleable as a fuel). It may be stated here that it is not yard sweepings, and it should contain no dirt or foreign matter whatever. Coke breeze for concrete, however, can always be improved by adding crushed clinker.

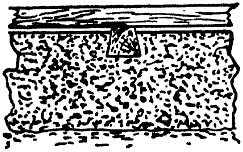

FIG. 111.

In practice this concrete, for floors, is usually made with Portland cement, 4 of breeze to 1 of cement, and laid 6 in. thick if on earth (ground floor), the floor boards, if boards are used, being laid slightly off the concrete as Fig. 111. Such a floor will carry a moving load of 1 ton. For first and higher floors, rolled steel joists enter into the construction, and then the concrete would have the boards lying close on it, as Fig. 112.

In Fig. 112, the concrete is shown coming next to the soil, but this is not satisfactory unless the ground be naturally dry. If laid on damp clay, it will probably sweat and give trouble.

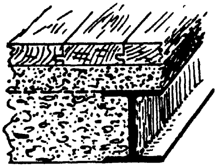

FIG. 112.

In such cases, a 6 in. top surface of earth should be taken out and replaced by 6 in. of dry broken brick rubbish well rammed, the breeze concrete being laid on this.

As coke breeze absorbs a rather large quantity of water, the concrete should be made rather more wet than when gravel or hard stone is used. In Fig. 111, the floor boards are shown slightly off the surface of the concrete to prevent contact and possible rotting, but many authorities consider that if the concrete is allowed to get thoroughly dry, say three to four weeks, the boards may go next to the concrete, if the soil beneath is of a dry kind. In other cases, the boards as laid are tarred on the underside, or coated with mastic (as wood-block flooring is laid). For mastic, *see* CEMENTS.

Concrete Floor for Wood Blocks.—This is composed of Portland cement and clean ballast, 1 and 6, and floated over with a ¾-in. layer of Portland cement and washed sand, 1 and 3. The floating should be worked to wooden screeds (*see* TILE LAYING), so as to secure a uniformly level surface, and these screeds may be left in. For laying wood block flooring, *see* CEMENTS *and* PAVEMENTS. If the concrete is laid directly on a damp soil, coat the floating with a bed of tar.

Causes of Cracking in Concrete Walls.—These are many and varied in character. In the case of lime, it is not unusual for two deliveries to vary in quality and character, and an unequal setting will tend to make a parting where the two kinds join. The same remarks apply to cement to, perhaps, a more pronounced extent, for fresh cement has quite different working qualities to that which has been air-slaked by turning it over three or four times under shelter. The expansion of cement may vary very greatly according to the air-slaking it has. Cracks may develop by reason of faults in the cement, even in the raw material from which the cement is made. Lime (in making cement) may create faults by being in too great a bulk. This may show great strength in itself, but the free lime does not slake until the cement is partly set. The clay (in making cement), if in excess, is a fault, being liable to contract in setting, and it has little strength. Magnesia in cement is a doubtful ingredient and in concrete subject to the action of sea water it is stated, that lime is washed out and magnesia takes its place (from the sea) causing expansion and flaking. Cement, if over fired in making, develops hard particles which escape the grinding, and which only slake after the body of the work is hard. This fault may not cause cracks, but is accountable for blisters and flaking. Slag used in making up the concrete may have lime in its composition in which case the slaking of this will cause trouble. It is needless to say, too, that lime as ordinarily used in lime-concrete must be thoroughly slaked before use. It is not an uncommon occurrence for imperfect cohesion to occur in making a concrete wall, due to carelessness on the part of the workmen. Bad mixing, the too liberal or improper use of water, and such acts, will make a bad joint. The same may be said if, when leaving the work at night, a proper "key" is not left for the morning's new work, and much the same bad effect is obtained if the work is badly planned, so that, in day-time, any part of the work is allowed to get dry (by a hot sun or drying winds), before the next portion is put on it. Frost too must be guarded against, as this will attack wet or "green" concrete, and cause disintegration. Irregular work results if the concrete is shot from too great a height as this tends to separate the small from the large material of the aggregate. This practice too is liable to disturb the partially set material already laid. A common cause of cracks is settlement of the earth on which the wall stands; while another, little understood as yet, is expansion and contraction. In retaining walls cracks are sometimes anticipated, so to speak, by making a succession of vertical straight joints at regular distances. In forming concrete arches, also concrete paving, it is as well to insert wooden strips at intervals, these being lifted out when the work is set and dry and then spaces grouted in with cement.

Reinforced Concrete, or Ferro-Concrete.—During the past few years the use of iron and steel for the purpose of strengthening concrete, particularly to admit of greater spans being dealt with, has grown rapidly in favour. This is not the older practice of making a large open lattice, or framework, of joists of various sizes and filling in the spaces with concrete, for this still prevails, but is a newer plan of embedding metal in the substance of the concrete to increase its general strength and admit, as stated, of its being carried over larger spaces without other support than it gets from the strength of the concrete, plus the metal embedded in it. In 'Page's Weekly,' a Mr. H. Kestner, who has made a speciality of this subject, describes Reinforced Concrete as being Portland cement concrete with iron or steel embedded in such a manner that both materials, intimately connected with one another, can jointly exercise a statical effect against external forces. The theory is based on the fact that the concrete resists compressive forces, while the iron bears the tensile stress, thus considerably increasing the otherwise limited tensile strength of the concrete.

The advantages of ferro-concrete constructions as compared with ordinary constructions, and the statical co-operation of the two otherwise so unequal materials, are based on the following accepted qualities of the same: (*a*) The concrete completely protects the enveloped iron against oxidation. (*b*) The adhesion of the Portland cement to the iron is very considerable, and nearly equal to the shearing strength of the concrete. (*c*) The coefficients of linear expansion through temperature are nearly equal. (*d*) When the iron surrounded by Portland cement concrete is subjected to a tensile stress, the expansion of the iron does not injure the concrete, as the latter expands with the iron, and, owing to its elasticity, recovers its former condition without, as above stated, its strength being impaired in the smallest degree. From the experiences gained, it is known that a safe protection against rust and a sufficient adhesion can only be obtained if the proportion of the mixture of the concrete is not too meagre, and if such an amount of water is added that the so-called plastic state of the concrete is obtained. It must be observed that the reinforced concrete, on account of the embedded iron and the comparatively small body of the concrete, cannot be rammed so well as is the case with ordinary concrete. Mr. Kestner takes as the lowest limit for the mixture constituents 1 to 6, especially with regard to the higher compressive strength of a richer concrete, as in all reinforced concrete constructions a high compressive strength of the concrete is imperative. As regards the adhesion of the concrete to the iron, 650 lb. per square inch, the result of exhaustive experiments by Prof. Bauschinger, is generally accepted. This value, however, according to Mr. Kestner, can in no way be regarded as normal. Through the latest experiments it has been proved that the adhesion of the embedded iron bars ceases when the strain in the iron exceeds the limit of elasticity. The adhesion of the concrete, therefore, varies proportionately to the diameter of the iron.

'The Builder,' in speaking of reinforced concrete, states, "that the most successful methods are those in which the reinforcement is in finely divided forms, these being arranged so that the stresses encountered may be adequately met." The application of this is to be found in the almost general use of rods, light bars, strips of metal, metal lattice and expanded metal. In Potter's patent, small corrugated steel tension rods are embedded, as Fig. 113. This firm also makes lintels, a test of two of which, 9 in. by 4½ in., placed on supports 4½ ft. apart, and subjected to a load of 20 tons equally distributed, gave 1 in. deflection, and were unbroken. In Homan and Rodgers' floors a pecu-

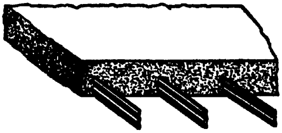

FIG. 113.

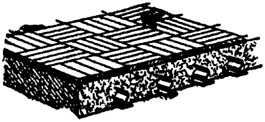

FIG. 114.

liar form of tee-bar is used, as Fig. 114. In Hodkin and Jones' system a corrugated strip, or bar, as Fig. 115, provides the reinforcement. The Columbian Fireproofing Co. use a ribbed steel bar, as Fig. 116, this illustration showing an ingenious method of suspending the bars. A final example may be given in Fig. 117, this showing Banks' system, in which a helical metal lattice lathing is used for reinforcement.

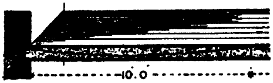

FIG. 115.

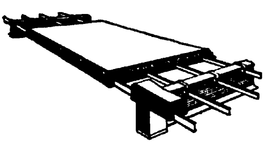

FIG. 116.

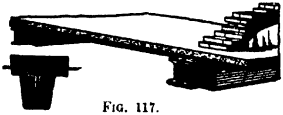

FIG. 117.

The examples represent but a few of the methods being adopted. All claim some superiority, but those capable of judging are of opinion that the technically correct plan is not yet decided, and more than one scientific society is investigating the subject at the moment of writing. There is not the least doubt that this method of construction will have a great future, not only for floors, but for very many purposes where ordinary concrete construction is more or less inadmissible.

Concrete Walls.—In the construction of walls or buildings of concrete, the latter has to be kept in place or supported by boards or otherwise, until dry and firm enough to be self supporting. Various kinds of suitable apparatus have been invented and patented, all more or less costly. A strong, simple, and inexpensive set may be made after the plan described and illustrated below. In Fig. 118, which is a perspective view, the boards *a b c d e* are each made of 3 planks *f* 9 in. wide and 1¼ in. thick, planed on the inner side. The width of each board is thus 2 ft. 3 in., and the length may be various—4 ft., 5 ft., 6 ft. The 3 planks *f* forming each board are held together by a piece of angle iron, screwed on at each end, which also serves to retain the bolts *g* by which the boards are secured to the uprights *h*. The last are formed of a strip of board 2 in. wide by about 6 ft. long, to which is secured a piece of channel iron (⊔) of the same width and length. The iron bolts *g* hold each pair of uprights at the required distance apart, to suit the thickness of the wall, as well as helping to tie together the boards on each side of the wall, and resisting the pressure of the moist concrete. As the wall advances in height, the bottom boards *c d e* can be removed and placed above the next row *a b*, and so on; and when the wall is sufficiently firm, the uprights can be removed and fixed higher. In addition to the straight boards, there will be needed some angle boards for turning corners.

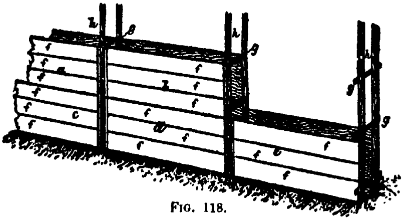

FIG. 118.

CONFECTIONERY, SYRUPS, LIQUEURS, CORDIALS, ETC.

(*See also* ESSENCES, EXTRACTS, PERFUMES, SUGAR, PRESERVING, ETC.)

Clarification.—For every 6 lb. of raw sugar required, take 1 qt. of water, the white of an egg, and about ½ teacupful of bullocks' blood. If a very fine, transparent, and colourless syrup is required, use finely powdered ivory-black instead of the blood. Put the white of egg in the water and whisk to a froth, then add the black and sugar, place the pan containing the ingredients on the stove-fire, and stir them well with a spatula, until the sugar is dissolved and nearly boiling. When ebullition commences, throw in a little cold water; this causes the coarser parts to separate more freely, and the impurities attach themselves to the clarifying matter used; continue for 5 minutes, using about 1 pint of water to every 6 lb. of sugar, until the dross is discharged, and there remains a fine clear syrup. Place the latter beside the stove, and carefully remove with a skimmer the scum which forms on the top: it may also be taken off as it rises, but it is best to let it remain a short time after it is clarified. When charcoal (black) is used, it must be passed through a filtering-bag made of thick flannel, in the shape of a cone, having a hoop fastened round the top to keep it extended, and to which strings are sewn that it may be tied or suspended in any convenient manner: what runs out at first will be quite black; return this again into the bag, and continue doing so until it runs fine and clear. A little lime or any other alkali, added to the sugar with the water, will neutralise the acid which raw sugars contain, and they will be found to stand better after they have been manufactured, by not taking the damp so soon.

Loaf-sugar is usually clarified by white of egg mixed with water, without other assistance. When it is necessary to have a very fine sparkling grain, break the lump into small pieces and put in a preserving-pan, with sufficient water to dissolve it, in which has been mixed the white of an egg and powdered charcoal, as for raw sugar, following instructions already given. After the sugar has been drained from the bag, pass some water through to take off any which may be left in the charcoal, and use for dissolving more sugar. The scum is reserved, when charcoal (black) is not used, to mix with articles of inferior quality.

Mr. W. Jago thus explains the various degrees through which sugar passes in making confectionery: The confectioner places in his pan say 7 lb. of white cube sugar or crystallised sugar, and 1 qt. of water. This is set on the fire and the contents raised to the boiling-point: directly this occurs, the liquid is carefully stirred with a spatula, so as to dissolve any lumps of sugar which may happen to remain. At this stage we have a solution of sugar in very hot water. On continuing the boiling a little longer, the temperature of the solution rises, and if taken by a thermometer, will be found to be at from 215° to 220° F. Each particular stage of temperature corresponds to a certain degree of sugar boiling, to which a technical name is given. Thus at the temperature of 215° to 220°, the degree of *smooth* is reached. The workman identifies these degrees by physical tests which he applies to the sugar. Thus he dips a clay-pipe stem into the liquid, and draws it between the finger and thumb; at the *smooth* degree the sugar feels oily, and hence the name of the degree. Proceeding still further with the heating, a temperature of 230° to 235° is reached, and now the sugar is at the *thread* degree. During this time water has been driven off from the sugar, and now on cooling, the solution is sufficiently viscous to draw into *threads*, if a little is pulled out between the finger and thumb. With further heating, a temperature of 240° to 245° is reached, and the sugar is in the *blow* or *feather* degree. At this stage the liquid has become so viscous that the steam generated in boiling *blows* the mass into huge bubbles, and in fact, may easily boil over the pan. If a little of the sugar be tossed in the air, it will exhibit a *feathered* appearance. At 250° to 255°, we reach the *ball* or *pearl* degree, and a little of the sugar taken on a pipe stem or glass rod and dipped into water acquires a consistency about equal to that of putty. We now proceed to carry our heating operation a considerable distance further, and when the thermometer registers from 310° to 316°, the sugar is at the *crack* degree. If now cooled in water, the sugar rapidly hardens and becomes *brittle*. Very little further heating causes an incipient caramelising, and the confectioner's *caramel* degree is reached.

During these stages the water originally added is being driven off; while toward the last the sugar is undergoing those successive steps of degradation towards caramelan, by "shedding" or losing molecule after molecule of water. It will be noticed that throughout, the sugar still retains the chemical composition of a carbo-hydrate.

Cutting the Grain.—At this stage an explanation must be given of what the confectioner terms "cutting the grain" of sugar. When heated above 250° F. the sugar will, if allowed to cool, crystallise into a hard granular mass. The sugar, in fact, re-solidifies from fusion and crystallises in so doing. To "cut" or destroy this graining tendency, the confectioner employs some acid substance, that most frequently used being cream of tartar, which consists of the acid tartrate of potash (hydrogen potassium tartrate). Instead of this, tartaric, citric, or acetic acids may be employed. The cutting agent may be added to the sugar when first mixed with water. As much cream of tartar as may be laid on a sixpence being added for 7 lb. of sugar, and the whole heated together. Sugar thus treated, instead of graining, remains pliable while hot, and transparent when cold. The sugar has in fact lost its crystalline nature, and has become an amorphous or vitreous substance.

Syrups.—(*a*) In the preparation of syrups, which are solutions of sugar more or less strong, according to the object for which they are used, care should be taken to employ only the best refined sugar, and either distilled or filtered rain water, as they will then be rendered much less liable to spontaneous decomposition, and become perfectly transparent without the trouble of clarifying. When, however, impure sugar is employed, clarification is always necessary. This is best done by dissolving the sugar in the water, or fruit juices, cold, and then beating up a little of the cold syrup with some white of egg and one or two ounces of cold water until the mixture froths well. This must be added to the syrup in the boiler, and, when the whole is frisked up to a good froth, heat should be applied, and the scum which forms removed from time to time with a clean skimmer. As soon as the syrup begins to simmer it must be removed from the fire and allowed to stand until it has cooled a little, when it should again be skimmed, if necessary, and then passed through a clean flannel. By using refined sugar, however, all this trouble of clarification can be avoided.

When vegetable infusions or solutions enter into the composition of syrups they should be rendered perfectly transparent by filtration or clarification before being added to the sugar.

The proper quantity of sugar for syrups will, in general, be found to be 2 lb. avoirdupois to every pint of water or thin aqueous fluid. These proportions allow for the water that is lost by evaporation during the process, and are those best calculated to produce syrup of proper consistence and possessing good keeping qualities. They closely correspond to those recommended by Guibourt for the production of a perfect syrup, which, he says, consists of 30 parts of sugar to 16 parts of water.

Preparation of Syrups.—In discussing at some length the various pharmacopœial methods for the preparation of syrups, W. Bernhardt, in a recent contribution to the 'Deutsch-Amerikanische Apotheker Zeitung,' comes to the conclusion that, with but very few exceptions, where heat would deleteriously affect the product, dissolving the sugar by heat and raising to the boiling point is the best. To ensure the best results the author lays down these rules :—

1. Employ only the best kinds of cane sugar, for the lower grades of sugar contain appreciable amounts of glucose, which inclines to fermentation. Follow closely the quantities directed in formula. Concentrated saccharine solutions resist fermentation in a much higher degree than more dilute ones. On the other hand, there will be loss from crystallisation, if syrups prepared by heat are stored in a cool room, as is sometimes done.

2. Use none but absolutely clear vegetable extracts, seeing to it that after ebullition the syrup may also be perfectly bright. The latter object may be accomplished by the customary aids, such as the addition of albumen or pure filtering paper pulp before bringing the syrup to a boil. This does not apply, of course, to naturally turbid syrup, as, for instance, syrup of almonds.

The author sets forth that even with most aromatic syrups the loss of volatile constituents can be but trifling, if the process of boiling be properly conducted. The inversion of saccharose may be left out of consideration, especially when fruit acids are absent, provided the solution of the sugar be completed at a low temperature and then rapidly raised to the boiling point. Albuminous substances are frequently extracted from the raw material, which boiling will remove; all fermentative germs and fungus spores are effectually destroyed by the heat.

Finally, to ensure perfect preservation, syrups should be filled into small vials (of from two to eight ounces capacity, according to individual needs) which have been placed into boiling hot water; the vials to be immediately corked and sealed. As an extra precaution, it is as well to lay the filled and corked bottles on their sides while yet hot, and to maintain that position. A French proposition is, to fill the bottles to the brim, and, while the contents are still warm, to place on top, so as to come in contact with the syrup, a circular piece of filtering paper. A firm cover of crystallised sugar is thus obtained, well calculated to exclude all extraneous matter. ('Western Druggist.')

Candied Sugar.—Provide a round mould smaller at bottom than top, of any size, made of tin or copper, with holes round the sides about 3 in. asunder, so as to fasten strings across in regular rows from the top to the bottom, leaving sufficient room for the sugar to crystallise on each string without touching, or it will form a complete mass; paste paper round the outside to prevent the syrup from running through the holes. Have the mould clean and dry; take sufficient clarified syrup to fill, boil to "blow" or "feather," and add a little spirits of wine; remove from the fire, and let rest until a thin skin is formed on the surface, which you must carefully remove with a skimmer; pour into the mould and place in the stove, where let it remain undisturbed for 8 or 9 days, at 90° F. (32° C.) or half that time at 100° F. (38° C.); make a hole, and drain off superfluous sugar into a pan placed below; let drain quite dry, which will take about 12 hours; wash off the paper from the mould with boiling water, place near the fire, and keep turning to warm it equally all round; turn up and strike the mould rather hard upon the table, when the sugar will relieve itself and come out; put on a stand or sieve in the stove, raise the heat to 120° F. (49° C.), and let remain until perfectly dry. The heat of the stove must be kept regular and constant; this can easily be accomplished at small expense with many of the patent stoves now in general use, and without causing any dust. A thermometer should be so placed that the heat may at all times be ascertained without opening the stove. Colour with prepared cochineal, or other liquid colour, or by grinding any particular colour with the spirits of wine and adding it to the syrup before it comes to the feather.

Confectionery Requiring No Cooking.—Excellent table confectionery can be readily, and quite easily made, at home, without cooking, and both quickly and inexpensively. The success of making this confectionery lies in the sugar used. It has to be the finest icing sugar, which, however, can be purchased quite cheaply (4*d.* per lb., retail). The confectionery has for its basis a dough made of this sugar moistened with the white of an egg, and an equal quantity of water; and this dough is rolled out and cut or otherwise formed into fancy shapes. It will be found that the sugar forms an excellent manageable dough as readily as good flour does. The finished sweets only take a few hours to dry ready for use, and they then eat about the same as a fondant or the white filling of an ordinary chocolate cream does. Flavouring and colouring are necessary, particularly the former. Confectionery made in this way will be found satisfactory, particularly those examples with chocolate and nuts in their composition, but it cannot be said to have the delicious smoothness of the cooked sugar-cream. This latter is described after the uncooked recipes, but it requires a little practice before good results can be depended on—even then there must be occasional failures. It is worth mastering, however, as a very superior sweetmeat is obtained.

To make the Sugar-Cream Basis for Uncooked Confectionery.—Put the white of an egg and an equal quantity of cold water into a basin. Add sufficient finest icing sugar, gradually, until the whole becomes a stiff dough. The white of one egg and the water will take up about 1½ lb. of sugar. If the whole of this is not wanted of one colour or flavour, it can be separated into parts when the dough is quite soft, and each given its distinctive flavour or colour before stiffening it with more sugar. Vanilla or any of the usual flavourings answer perfectly and dry powdered chocolate or cocoa can be worked in the same as the dry sugar. Chocolate or cocoa give an attractive brown shade; carmine can be used for pink; and other vegetable colourings serve equally well. When the flavouring and colouring are done, and more sugar worked in to stiffen the mass, use at once. The finished sweets seem to improve with one or two days' keeping, but are eatable if required in about six hours.

Plain Cream Squares.—Make some plain sugar cream, as described, and flavour with a few drops of vanilla essence, raspberry, almond, or other flavouring. Dust a pasteboard over with icing sugar, and rub the rolling pin with the latter. Put the cream on the board, roll out to ¾ in. thickness, and cut into square or oblong pieces with a knife. Dust over a smooth metal sheet or tray with icing sugar, and place the squares on to dry.

Chocolate-flavoured Cream Squares. Make some sugar cream, as described, but when a quite soft dough has been made, cease to add sugar, and finish it with chocolate or cocoa powder instead. Add vanilla or almond extract. Roll out the mass and cut into squares, as described above.

Neapolitan Squares.—Make some plain sugar cream, as described, and separate it into three or more parts. Flavour one part with vanilla, and leave this white. Flavour the second part with raspberry or rose, and colour this pink with two or three drops of carmine. Add powdered chocolate or cocoa to a third part and mix it thoroughly in, adding a few spots of water if necessary. Roll each out on a board, previously dusted over with icing sugar and rubbing this sugar on the rolling-pin. When ½ in. thick, place the layers on top of one another, the white one in the middle, and lightly press together. Cut into squares, and place them to dry on a smooth tin or tray, which has been dusted over with sugar.

Nut Cream Squares.—Make some plain sugar cream, as described. Flavour this with ratafia or almond. Or it is very nice if a small quantity of chocolate is mixed in, as the flavour of this latter goes very well with nuts. Chop up, not finely, some mixed nuts such as almonds, walnuts and filberts, in quantity nearly equal to the cream. While the cream is moderately soft, add the nuts and gently knead them in. Preserved fruits, glacé cherries, raisins, figs, etc., can be used instead of nuts, and the finished article is then called Fruit Cream Bars.

Almond or Walnut Creams.—Make some plain sugar cream, as described, and flavour it with almond or ratafia essence. Colour it with a few drops of carmine for a pale pink; or with sufficient chocolate to give it a pale fawn colour. Make into balls; insert the point of a knife to make an opening, and insert a bleached almond in each; or lay half a walnut on top. Place away to dry, as described.

Coffee Creams are made as just described, but strong coffee is used instead of water in making the sugar dough. Half-walnuts are pressed on top.

Cream Cherries.—Take some plain sugar cream, as described, and flavour with a few drops of vanilla. Form into balls the size of small cherries. Take some glacé cherries, and cut them in halves. Press a half cherry on each side of the ball. This will slightly flatten the ball, which is rather desirable. Cut some strips of angelica to form the stalks, and insert them. Place away to dry.

Chocolate Creams.—Make some plain sugar cream, as described. Flavour with vanilla, rose, lemon, or any essence preferred. Form into balls or pyramids, and put aside to dry for about four hours or longer. Melt some chocolate in a double saucepan, or in any vessel over steam. When the creams are dry, dip one in the melted chocolate, letting it rest on the end of a narrow fork. With a knife scrape off the chocolate beneath the fork, then slip the cream on to buttered paper to cool and set. Do all like this. The chocolate should not be too hot, it must be thick enough to well coat the creams, and not run thin at the tops.

Marzipan.—Take ½ lb. of blanched almonds, ¾ lb. of finest icing sugar, the white of one egg and the juice of half a lemon. Pound the almonds to a paste in a mortar, then add the other ingredients, and pound all well together. This confection can be eaten alone, cut into small squares, or serves excellently as a filling for chocolate sweets. One layer of this could be used with advantage in making the Neapolitan squares described. It is very delicate eating.

Assorted Creams, made with Fresh Cream, Uncooked. — (These do not keep more than a day or two.) Take some finest icing sugar, and free it perfectly from lumps. Put it into a basin, and work in sufficient thick sweet cream to make into a ball or dough which can be cut or worked into shapes. Divide into three or four parts and flavour them differently. Any of the shapes described in the preceding pages can be made with this sugar cream. These creams are delicious flavoured with any fresh fruit juice, but, if this is done, either more sugar or less cream must be used.

Confectionery requiring Cooking. *Cooked Sugar Cream.*—In appearance there is little distinction between the uncooked and the cooked sugar cream sweetmeats, but the latter are superior in smoothness and delicate eating. It would be better always to make cooked sugar cream, only that it takes longer and there are many failures at first. It costs no more. Care and some experience are needed in all sugar-boiling processes, as a little too much cooking, stirring, or even shaking at the wrong time, and quite small things, make a failure, which necessitates commencing again. If the following directions are carefully adhered to, the novice will soon find how to get a successful ending. Put 1 lb. of best loaf sugar into an enamelled saucepan with a small cupful (a tea-cup) of cold water. See that the sugar melts, and when it begins to boil do not stir or touch it in any way for 8 minutes. It will not burn. Dip an ivory bodkin or wooden skewer gently in and lift it out, and take a small drop from the end of the skewer between the finger and thumb. The fingers should be previously wetted to save burning them. Open the finger and thumb, and if the sugar threads even a little it is done. The boiling may vary from 8 to 11 minutes, depending how fast it is. It is better to boil gently. Up to now the boiling sugar has not been stirred or shaken, and the pan should be lifted gently from the stove without shaking it, and placed somewhere to cool until the sugar can be just touched with the fingers without being burned. This will be in about 10 to 15 minutes in a cool kitchen, depending on whether the sugar is spread out in a large basin or more in bulk in a small one, and also depending on the quantity cooked at one time. When cooled to this extent (it should be rather too hot than too cool), pour it into a bowl and beat well with a wooden spoon until it becomes a thick white and glossy cream. When stiff enough, take it out into the hands and knead well. It then becomes a soft, manageable dough, very smooth and not in the least grainy in the mouth like uncooked sugar cream. The important points are correct boiling, no disturbance or shaking before it is cool enough, yet it must not be allowed to get too cool. If it goes hard or grainy, it shows too much boiling, disturbance of some kind, or allowing it to get too cold. If this should happen, the sugar can be used up again for the same purpose quite satisfactorily by adding a proper proportion of water. When the dough is ready, it can be divided and used for any of the cream sweetmeats already described with uncooked cream, or fashioned into any other shapes; in fact, there is scarcely a limit to the exercise of one's ingenuity with this tractable substance. Any suitable flavouring and any vegetable colouring may be used.

Candied Fruits.—Put ½ lb. of cane sugar on to boil with a ½ pint of water, in a bright saucepan. Boil the sugar to the "crack." This is when a little taken in a spoon and dropped into cold water, immediately sets, so that it will break short. When the syrup has boiled to this degree, remove it from the fire. Dip the fruits in carefully, immediately remove any sugar hanging beneath, then lay them on a dish or marble slab. Tangerine orange, nuts, and other fresh fruits are excellent treated in this way. Preserved confections such as glacé cherries, angelica, crystallised violets and such like, can be candied in this way, and make a very pretty ornamentation for sweet dishes. For this purpose, the fruit is first stuck on a skewer; then, when dipped, a long string of the syrup is allowed to hang from it, and this is laid on the dish. When set, the fruit is found to have a long candy spike attached, and this is stuck into the pudding mixture.

Candied Chestnuts.—Take some large chestnuts, and remove the outer skins. Put the nuts into boiling water and boil for five minutes. Remove the inner or second skins, which should then come off quite easily. Be careful to reject decayed or unsound nuts. Now throw them into some fresh boiling water, and boil until tender. Take the nuts carefully from the pan, and this pink with two or three drops of carmine. Add powdered chocolate or cocoa to a third part and mix it thoroughly in, adding a few spots of water if necessary. Roll each out on a board, previously dusted over with icing sugar and rubbing this sugar on the rolling-pin. When ¼ in. thick, place the layers on top of one another, the white one in the middle, and lightly press together. Cut into squares, and place them to dry on a smooth tin or tray, which has been dusted over with sugar.

Nut Cream Squares.—Make some plain sugar cream, as described. Flavour this with ratafia or almond. Or it is very nice if a small quantity of chocolate is mixed in, as the flavour of this latter goes very well with nuts. Chop up, not finely, some mixed nuts such as almonds, walnuts and filberts, in quantity nearly equal to the cream. While the cream is moderately soft, add the nuts and gently knead them in. Preserved fruits, glacé cherries, raisins, figs, etc., can be used instead of nuts, and the finished article is then called Fruit Cream Bars.

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Confectionery requiring Cooking. *Cooked Sugar Cream.*—In appearance there is little distinction between the uncooked and the cooked sugar cream sweetmeats, but the latter viously well dried). Stir quickly, and turn out on to a buttered dish. It can be worked a little with oiled hands.

Marzipan.—This is a recipe for cooked marzipan; the uncooked has been described. Blanch 1 lb. of sweet almonds. Put these into a mortar with a few bitter ones, add a few spoonfuls of rose-water, then pound the whole smooth. Put this into a stewpan with 1 lb. of icing sugar, and stir over the fire until a smooth paste is obtained, which will not stick to the fingers when touched. Sprinkle a paste-board with icing sugar, then roll out the paste. Divide it into cakes, then place them on sheets of paper on a baking sheet. Bake in a slow oven until it is a pale yellow colour.

Rahat Lahum (*Turkish Delight*).—Make a syrup with 3 lb. icing sugar and 3 pints of water. Clear it with the whites of three eggs and the juice of a lemon. Dissolve 6 oz. of pure wheat starch in ¾ pint of cold water, strain it, and add it to the clear syrup when it is boiling. Reduce the whole by boiling to two-thirds. It should then be very thick and stringy. Flavour the paste with attar of roses or any sweet essence. Have ready a large dish well covered with almond oil. Empty the paste on the dish when it is cool, spread it about 1 in. thick. Have ready another dish covered with finely powdered sugar, and when the paste is quite cold, turn it over very carefully upon the sugared dish. Absorb the oil with blotting paper, and cut the paste into pieces 2 in. square. Powder them with sugar, and keep very dry. A fine rahat is made with rose or cherry syrup, with blanched almonds stirred in before the paste thickens.

Barley Sugar.—Put 1½ lb. of loaf or caster sugar into a well tinned saucepan, and add ½ pint of water and half the white of an egg. Mixed well together. Bring to the boil and skim carefully. As soon as the scum ceases to rise, the sugar is clarified, but it is best to then strain it through muslin. Put it back into the pan and boil it to the crack, so that a little dropped into cold water becomes hard and brittle. Remove from the fire, add a teaspoonful of lemon juice, and after letting it stand for a minute, pour out on to an oiled dish. Before it is set hard, cut into strips and twist them, or small squares; or it can be dropped while hot into lozenge-shaped drops.

Butter Scotch.—Put 1 lb. of Demerara sugar into a saucepan with a teacupful of water. Boil until a little dropped into cold water immediately becomes hard and brittle. Add 2 oz. of fresh butter, and boil four or five minutes longer. Pour on to a buttered dish and cut into oblong pieces.

Everton Toffee.—Put a ¼ lb. of fresh butter into a tinned saucepan, and when partially melted add ½ lb. of treacle and ½ lb. of Demerara sugar, and mix well together. Boil for eight or ten minutes, then test it by dropping a little in cold water. If it immediately hardens and is brittle, pour all on to a buttered dish. Before it is hard it can be marked into squares with the back of a knife, and it will then break evenly. If liked, almonds can be pressed in before the toffee hardens. Toffee can be pulled until it is any desired light colour, or even white. It is then, while soft, made into rolls or sticks about ½ in. thick, and cut into short pieces with scissors. This makes an excellent toffee. Half the quantity of butter can be used and it still produces a good sweetmeat, provided the sugar and treacle are of good quality (golden syrup is better than black treacle).

Almond Hardbake.—Mix together 1½ lb. of moist sugar and ¾ pint of cold water. Put these into an earthenware pipkin and boil until a little dropped into cold water immediately becomes hard and brittle. Have ready 3 oz. of almonds, blanched and split lengthways. Add these, with 3 oz. of butter, to the boiled sugar. Boil again, until a little dropped into cold water hardens immediately. Pour the hardbake on to an oiled or buttered dish to set.

Coco-nut Candy.—Mix together 1 lb. of loaf sugar with ½ pint of cold water, in an earthenware pipkin. When the sugar is dissolved, boil for about five minutes. Carefully remove all scum as it rises. Now mix in a ¼ lb. of desiccated coco-nut, or fresh-grated or sliced coco-nut. Boil up again, and when the candy rises quite up in the pipkin, remove the latter from the fire and then spread the candy about ½ in. thick on well dried and warm sheets of writing-paper. When nearly cold, remove the papers and cut the candy up into neat squares. If desired, the candy, or part of it, can be given a pink tint by adding a few drops of carmine.

Sugar Sweets Boiled to "Crack." *Acid Drops and Sticks.*—(*a*) Boil clarified sugar to crack, and pour it on an oiled marble stone; pound tartaric or citric acid to a fine powder, and strew about ½ or ¾ oz. of the former, according to its quality, and less of the latter, to 7 lb. sugar; turn the edges over into the middle, and mix the acid by folding over, or by working as dough is moulded, but do not pull it; put in a tin rubbed over with oil or butter, and place under the stove to keep warm; then cut off a small piece at a time, and roll into a round pipe; cut off in small pieces the size of drops, with shears, and let your assistant roll them round under his hand and flatten them. Mix with powdered sugar, sift from it, and keep in boxes or glasses. When flavoured with lemon, they are called lemon-acid drops; with otto of roses, rose-acid drops. The sticks are made in the same manner as the drops, without being cut into small pieces.

(*b*) *Acid Drops.*—These are best made with loaf sugar. To 10 lb. put ½ oz. cream of tartar with the water, and boil to crack. Pour on the stone, and work in 2½ oz. finely powdered tartaric acid. Instead of making into drops by hand, this is now done by a machine, called a "drop machine." The rollers are either slightly oiled before a thin sheet of the sugar is passed through them, or the sheet of sugar itself is dusted with finely powdered sugar. In large establishments, all kinds of drops, balls and sticks are made by machine.

Almond Hardbake.—Oil a square or round tin with low edges; split some almonds and put in rows over the bottom, with the split side downward, until the surface is covered; boil some raw sugar to crack, and pour it over so as to cover the whole with a thin sheet of sugar. Coco-nut cut in thin slices, currant, and other candies, are made as the hardbake, except that the sugar is grained before it is poured over.

Almond Rock.—This is similar to nougat, and is made with raw sugar boiled to crack. Pour on an oiled stone, and fill with sweet almonds, either blanched or not; the almonds are mixed with the sugar by working them in with the hands, as you would mix anything into a piece of dough. If they were stirred into the sugar in the pan, it would grain, which is the reason why it is melted for nougat. Form the rock into a ball or roll, and make into a sheet about 2 in. thick, by rolling with a rolling-pin. The top may be divided into diamonds or squares by means of a long knife or piece of iron; when nearly cold, cut it into long narrow pieces with a strong knife or hammer.

Barley Sugar.—Boil clarified loaf sugar to crack or caramel, using a little acid to prevent graining; pour out on a marble slab, which has been previously oiled or buttered. This is occasionally flavoured with lemons. When required, pour a few drops of essential oil of lemon in the centre, before the edges are folded over, then cut into narrow strips with a large pair of scissors or shears. When nearly cold, twist, put into glasses or tin boxes, and keep closed to prevent the access of air. It is seldom boiled higher than crack, and saffron is used to make it the colour of caramel.

Barley Sugar Drops.—Boil sugar as for the preceding. Spread finely powdered and sifted loaf sugar on a table or teatray, with a piece of stick round at the end; make several holes, into which run the sugar from a lipped pan; or drop on an oiled marble slab with a funnel, letting only one drop fall at a time; or from the lip pan, separating each drop with a small knife or a straight piece of small wire. Take off the stone with a knife, mix with powdered loaf sugar, sift from it, and keep in glasses or tin boxes.

Barley Sugar Tablets or Kisses.—Spread sugar as for the last; have a piece of wood about 1½ in. thick, with the surface divided into 1-in. squares ½ in. deep; with this form the impressions in the sugar, and fill with sugar boiled as for drops, flavouring with essence of lemon; or it may be poured out in a sheet on an oiled marble slab, as for barley sugar, and when nearly cold divided into pieces with a tin frame, having small square divisions, when the whole sheet may be divided at once by pressing hard on it so as to cut it nearly through. When cold, separate, and mix with powdered sugar; take out and fold separately in fancy or coloured papers, with a motto on each. They are also occasionally made into balls, thus—First cast the sugar into a sheet on an oiled marble slab; when the edges are set, fold them in the middle, then oil a small square tin with edges to it, put the sugar in this, and place under the fire-place of the stove so as to keep warm; cut off a piece and roll into a pipe, then cut into small pieces with a pair of shears, and let your assistant roll it into small balls under his hand on a sand-stone; marble is too smooth for this purpose. Lads who are used to it can turn 8 or 10 under each hand at one time. When finished, put into powdered sugar, wrap in fancy papers fringed at the ends, put a motto in each, and fasten with small bands of gold paper. Sometimes a cracker is folded up in each; this is made with two narrow strips of stiff paper, a small piece of sand or glass paper pasted on the end of each, these are placed over each other with a little fulminating powder between, a piece of thin paper is bound round it, and pasted to keep them together; when these are pulled asunder, the two rough surfaces meeting cause the powder to explode, and out flies the ball of sugar with the motto.

Brandy Balls.—These are made from loaf sugar, boiled to crack, coloured with either cochineal or saffron, and finished the same as acidulated drops without being flattened.

Clove, Ginger, or Peppermint Rock.—These are all made in the same way as raspberry, using the essential oil of each for flavour. For clove, the mixture, whilst boiling, is coloured with cochineal; ginger, with saffron; but the peppermint must be kept perfectly white, except the stripes, which is done by cutting off as many pieces from the bulk as you have colours, which should be in powder; put a sufficiency in each piece to give the desired tint, and keep warm. When the remaining portion of the sugar is pulled, lay them over the surface in narrow stripes, double the roll together, and the face each way will be alike. Pull out into long sticks, and twist; make round by rolling under the hand; or cut into small pieces with a pair of shears, or scissors, for pellets, pincushions, etc.

Raspberry Rock or Sticks.—This may be made from raw or refined sugar. Boil to crack, and colour with cochineal; pour it on a stone rubbed with a little oil or butter; cut off a small piece, and keep warm to stripe or case the other part, when finished; to the remainder add a little tartaric acid (not so much as for drops), and some raspberry-paste to flavour it. The residue of raspberries used for making vinegar, and preserved with an equal quantity of sugar, or even less, as for raspberry cakes, does very well for this purpose. Fold the edges over into the centre, and attach to a hook fixed against the wall; pull towards you, throwing it on the hook each time after having pulled out; continue until it gets white and shining; then make into a compact long roll, and either stripe with the piece cut off, or roll in a sheet with the rolling-pin, and wrap round so as to form a sort of case; then pull into long narrow sticks, and cut the required length.

Raspberry Drops are made as acid drops, with the addition of orris powder, and the sugar is coloured red in the boiling with prepared cochineal.

Lozenges.—Lozenges are compounded of finely powdered loaf sugar and other substances (liquid or powdered), held together in a paste by means of gum solution, then rolled into thin sheets, and stamped into little cakes. The chief precaution necessary is to have the gum of sufficient tenacity. Some gum solutions used are: (1) 1 oz. tragacanth, ½ pint water; soak in a warm place for 24 hours; put into a coarse cloth, and twist until all the gum has been squeezed out; 1 oz. of this dissolved gum suffices for 4 to 5 lb. sugar. (2) 1 oz. dissolved gum arabic to 12 oz. sugar. (3) 1 oz. tragacanth and 3 oz. gum arabic. (4) 1 lb. gum arabic dissolved in 1 pint water, for all but "medicinal" lozenges. (5) 2½ lb. gum arabic dissolved in 1 qt. water, and 1 oz. tragacanth in ½ pint water, for all lozenges.

Peppermint. — (1) Double-refined loaf sugar, pounded and sifted through a lawn sieve: make a bay with the sugar on a marble slab, pour in some dissolved gum, and mix into a paste as dough, flavouring with oil of peppermint. Some prefer mixing the gum and sugar together first in a mortar. Roll out the paste on a marble slab until it is about ⅛ in. thick, using starch powder to dust with, to prevent sticking to the slab and pin. Before cutting out, strew or dust over the surface with powder mixed with lawned sugar, and rub over with the heel of your hand, which gives a smooth face. This is termed "facing up." Brush off, and again dust the surface with starch powder, cut out, and place in wooden trays. Put in the stove to dry. All lozenges are finished in the same manner. (2) As (1), adding a little starch-powder or prepared plaster as for gum paste to the paste, instead of using all sugar. (3) Use more starch powder in proportion; smaller cutters, and the paste rolled thicker. (4) Transparent. These are made from loaf-sugar in coarse powder; mix into a paste with dissolved gum arabic and a little lemon-juice. Flavour with oil of peppermint. (5) Superfine transparent. The sugar must be in coarser grains. Mix and flavour as the others. The coarser the grains of sugar, the more transparent the lozenges. The finest particles destroy transparency. The solution of gum should be thicker in proportion as the sugar is coarse.

(6) The commonest peppermint lozenges are made with half farina (prepared starch), and half loaf-sugar, of second quality. A little smalt blue is added to make them of a good colour.

Rose.—Make paste as peppermint (1), using otto of roses to flavour; or the gum may be dissolved in rose water, and a little essential oil added if required. Colour with carmine.

Burnt Almonds.—Take fine Valencia or Jordan almonds, and sift all the dust from them; put a pint of clarified syrup into the pan for each lb. of almonds, and place it with the almonds on the fire; boil to "ball," then take off and stir the mixture well with a spatula, that the sugar may grain and become almost a powder, whilst each almond has a coating. Put into a coarse wire or cane sieve, sift all the loose sugar from them, and separate those which stick together. When cold, boil some more clarified syrup to feather, put in the almonds, give 2 or 3 boils in it, take from the fire, and stir with the spatula as before, until the sugar grains; sift and separate, and keep in glasses or boxes. A third coat may be given in the same manner as the second, if they are required large.

Red.—The same as the last, using prepared cochineal to colour the syrup whilst boiling.

Common.—These are made with raw sugar and skimmings. Put some water with the sugar to dissolve it; when near boiling, add the almonds, and let boil in it until it comes to small ball; or when the almonds crack, take from the fire and stir with a spatula until the sugar grains and becomes nearly a powder; put into a sieve, and separate the lumps.

Best Burnt Almonds. Red.—For each lb. of sifted almonds, use 2½ lb. loaf-sugar, made into a syrup. A round-bottomed copper pan is best for making these in. The almonds may be boiled in the sugar until they crack, before being taken from the fire to be stirred and separated from the second coat; or, when the sugar is boiled to ball, the almonds may be put in; then take from the fire, and stir well with a spatula, that the sugar may grain, and each almond have a coating. Put the pan on the fire again, and keep constantly stirred, that the loose sugar may melt and burn about them of a fine brown. Either way will give the burnt flavour, from which they take their name. Turn into a coarse sieve, sift all the loose sugar from them, and separate those that stick together. Boil the same quantity of clarified syrup as before to feather and colour it to the desired shade with prepared cochineal. Let it attain the same degree again before taking the syrup from the fire, then put in the almonds and stir them as before until the sugar grains, and again sift and separate. The sugar for the third coating must not be boiled quite so high as the last, and there must be only sufficient to just cover them. Immediately the sugar begins to grain about them, turn out on the stone, and cover with a pan or cloth. After a few moments, separate and put in boxes or glasses, when cold.

The colour of these almonds is considered to be much brighter when the syrup is boiled rather higher than the required degrees for the second and third coats, and the colour added to reduce it, after it is taken from the fire.

Coco-nut Ice, or Candy.—Finely grate the inside of a coco-nut; mix 6 or 8 oz. of the grated nut with 1 lb. sugar; use water to moisten the sugar in the proportion of 1 pint to 3 lb. Boil to bare crack, grain the sugar by rubbing some against the side of the pan, and pour into oiled or buttered tins. Some give an additional flavour by adding a little raspberry jam, or orris powder (which will also give somewhat the flavour of a raspberry, if a little tartaric acid is used with it). With the jam more particularly it forms a most delicious compound. It should be coloured with prepared cochineal to give the red colour of raspberries, otherwise it should be white. Machines are now generally used for preparing the coco-nut.

Colt's-foot Rock.—1 lb. Spanish liquorice dissolved in ¾ pint water; 2 oz. tragacanth dissolved in 1¼ pint water; 28 lb. icing sugar, 1 oz. essence of lemon, 2 oz. extract of poppies. Colour with Spanish brown. Make into a paste. Force through a metal tube with a plate at the bottom, having holes at the bottom similar to a star, by the means of a screw. Cut into lengths, and dry.

Chewing Gum.—(*a*) Sugar 2 oz., gelatine 10 oz., dissolve in sufficient hot water to make both ingredients fluid, then let it cool and set in moulds. (*b*) 6 drachms sugar candy, 6 drachms gum tragacanth, 3 oz. isinglass, 3 oz. parchment glue. Dissolve in just sufficient hot water to make all fluid, then cool in moulds. Flavouring is added to taste.

Crystallised Fruits.—Have a square or round tin box, smaller at bottom than top, with wire gratings made to fit at convenient distances, and having a hole with a tube or pipe to admit a cork, and drain off the syrup. Take any preserved fruit wet, drain from the syrup, and dip in lukewarm water to take off any syrup which may adhere; dry in the stove; when dried, place in layers on the gratings, side by side, so as not to touch each other; continue in this manner with any sort of fruit until the box is full; then fix the whole with a weight, to keep it steady. Boil sufficient clarified sugar to fill the box to the degree of "blow," add a little spirits of wine, and remove from the fire. When a thin skin has formed on the top, remove carefully with a skimmer, and pour the sugar into the mould; place in the stove at 90° F. (32° C.), and let remain for 12 hours; drain off the syrup into a pan from the tube at bottom, and let remain in the stove until quite dry; turn out by striking the box hard upon the table, separate carefully, and put in boxes with paper between each layer. When different fruits, paste, knots, etc., are mixed together indiscriminately, it is termed mille-fruit candy. Any sort of fruit or gum pastes, when thoroughly dried, may be crystallised in the same manner. When the syrup is drained off, if the crystals are not large enough, another lot of syrup may be prepared and poured over; let remain in the stove for 7 or 8 hours, then drain and finish as before. If small pieces of stick are pushed down at each corner, or in any other vacancy, when filling the mould, one may be withdrawn at any time to ascertain the size of the crystals, which will save the trouble of giving a second charge of sugar.

Drops.—Take treble-refined sugar with a good grain, pound, and pass through a coarse hair sieve; sift again in a lawn sieve, as the sugar, when too fine, makes the drops compact, and destroys their brilliancy. Put some of the coarse sugar into a small drop pan (with a lip on the right side, so that when held in the left hand the drops may be detached from it with the right), moisten with any aromatic spirit, and sufficient water to make it of a consistence just to drop off the spoon or spatula without sticking to it. Colour with any colouring matter. Place the pan on the stove fire, on a ring of the same size. Stir occasionally until it makes a noise, when it is near boiling: do not let it boil; take from the fire, and stir well with the spatula until of the consistence that when dropped it will not spread too much, but retain a round form on the surface. If too thin, add a little of the coarse sugar, reserved for the purpose and made of the thickness required. Have very smooth plates, of tin or copper, quite clean; drop on these, separating the sugar from the lip of the pan with a piece of straight wire, as regularly as possible. About 2 hours afterwards they may be taken off with a thin knife. If you have no plates, drop on smooth cartridge paper. Wet the back of the paper to take them off. Cover the bottom of a sieve with paper, lay them on, and put in the stove for a few hours, but not long enough to deprive them of their fragrance.

Catechu.—1 lb. sugar, 3 oz. catechu. Make as violet. May also add musk or ambergris—about 15 gr.

Chocolate.—1 lb. sugar, 1 oz. chocolate. Scrape the chocolate to powder, mix with the sugar in coarse grains, moisten with clean water, and proceed; do not mix more than can be dropped out whilst warm at one time. If any remains in the pot, it will grease the next, and will not attain the consistence required.

Cinnamon.—1 oz. cinnamon, 1 lb. sugar. Pulverise the cinnamon, and sift through a lawn sieve. Mix with the sugar, and add 2 or 3 drops of the essential oil, if the flavour is not strong enough. Moisten with water and proceed. The flavour may be given with essential oil only, colouring with bole ammoniac.

Clove.—As cinnamon.

Coffee.—1 oz. coffee, 1 lb. sugar. Make a strong clear infusion of coffee, as for coffee ice, and use to moisten the sugar. Make the drops as chocolate.

Ginger.—Mix sufficient best powdered ginger to give the desired taste, or flavour with essence of ginger, and colour with saffron. Moisten with water, and make as others.

Lemon.—Rub the yellow rind of

lemons on a piece of rough sugar, scrape off, and mix with the coarse sugar. Use sufficient to give a good flavour, and colour with saffron ; moisten with water, as others.

Orange-flower.—Use orange-flower water to moisten the sugar, or flavour with essence of neroli and moisten with water.

Orgeat. — Make milk of almonds, using a little orange-flower water; moisten the sugar with it.

Peppermint. — Moisten the sugar with peppermint water, or flavour with essence of peppermint, and moisten with water.

Raspberry.—Press the juice of ripe raspberries through a piece of flannel, and moisten the sugar with it.

Rose.—Moisten the sugar with rose water, and colour with cochineal.

Vanilla.—As cinnamon, using a little sugar to pound the vanilla ; or may be moistened with essence of vanilla, but this greases it as chocolate.

Violet.—1 lb. sugar, 1 oz. orris powder ; moisten, and colour violet.

All fruit drops are made with expressed juice, except orange. When you first rub the rind of the fruit on sugar, squeeze the pulp of the fruit, and pass through a hair sieve. Scrape off the sugar on which the rind was rubbed, mix with sufficient pulp to give the desired flavour, and moisten with water. These grease the sugar, and require the same precautions as chocolate drops.

Comfits. — These are made in a copper comfit-pan, attached to a bar, having chains at each end, with a hook and swivel in the centre, by which it is suspended from the ceiling about breast high over a stove or charcoal fire. Steam pans are now used in large factories. A preserving-pan containing clarified syrup is placed inside the stove, or over another fire, that it may be kept hot, but not boiling ; a ladle for throwing syrup into the pan, and a "pearling cot," are also needed. This last somewhat resembles a funnel without the tube, and having a small hole in the centre with a pointed spigot fitted into it, which regulates the syrup run out. A piece of string tied several times across the centre of the top of the cot, and twisted with the spigot, allows it to be adjusted.

Caraway.—(1) sift 2 lb. caraway seeds in a hair sieve to free them from dust, put into the comfit-pan, and rub well about the bottom with your hand until quite warm ; have some clarified loaf sugar syrup boiled to "small thread" ; give a charge by pouring over about 2 tablespoonfuls ; rub and shake well about the pan, that they may take the sugar equally, until quite dry. Be careful not to make them too wet in the first charges by using too much syrup, or they will lie in a lump and be difficult to part. It prevents sticking to pass the hand through them between every swing of the pan, and adds to their smoothness. Give 4 or 5 charges, increasing the quantity of syrup a little each time, and let each charge be well dried before another is given, dusting with flour at the last charge. Sift in a hair sieve, and clean the pan. Put in again, and give 4 or 5 charges more, with a dust of flour at the last ; then sift, and clean the pan. Proceed thus until they are ⅓ required size. Put in the stove or sun to dry until next day ; clarify and boil some sugar to large thread, keep warm as before, divide the comfits, and put part in the pan, so as not to have too many at one time ; as they increase in size, divide into convenient portions, so as to work them properly without encumbering the pan. Give 4 or 5 charges of syrup, proceeding in the same manner as before, until they are ⅔ or more of the required size ; stove until next day. Continue with each portion alternately, until all are done. On the third day, boil the syrup to small pearl, and give 8 or 10 charges as before, without using flour, lessening the quantity of syrup each time. Swing the pan gently, and dry each charge well. Put in the stove for ½ or 1 hour after each charge, and proceed alternately with each portion until finished, when they should be about the size of peas. Put in the stove for a day, then smooth with the whitest loaf sugar syrup boiled to small thread; add 2 or 3 tablespoonfuls of dissolved gum arabic to give a gloss. Give 3 or 4 charges with a very gentle heat, the syrup being cold and the pan scarcely warm. Work and dry each charge well before another is added; when finished, dry in a moderate heat. It is best to dry comfits in the sun, as it bleaches them. If the stove is at a greater heat than the sun on a moderately warm day, which is 70° to 80° F. (21° to 27° C.), it will spoil their whiteness. (2) Bath Caraways are made in the same way, but only half the size. (3) Gingerbread Caraways. Sift the seeds, and warm in the pan, as for (1). Have some gum arabic dissolved, throw in a ladleful, and rub well about the pan with the hand until dry, dusting with flour. Give 3 or 4 coatings in this manner, and then a charge of sugar, until the comfits are about ½ the required size. Dry for a day, give 2 or 3 coatings of gum and flour, finish by giving 3 or 4 charges of sugar, and dry. These are made about the size of Bath Caraways. Colour some different colours, leaving the greatest portion white. (4) Pearled. When the comfits are about the size of Bath caraways, dry and pearl as cinnamon.

Cardamon.—Keep the seeds in their husks until used. They are often mixed with grains of paradise, which have not the same aromatic taste, and are more hot and spicy. Break the husks by rolling with a pin; separate the skins from the seeds, put 2 lb. into the comfit-pan, and proceed as for caraways (1). Make a good size, and quite smooth.

Celery.—Put 1 lb. celery seed into the pan, and proceed as for caraways (1), working up to the size of a large pin's head. Dry and pearl as cinnamon.

Cinnamon.—Take 1 lb. cinnamon bark, and steep in water for a few hours to soften; cut into pieces about ½ in. long, and the size of a large needle. Dry in the stove. Put the pieces, when dry, into the comfit-pan, and pour on a little syrup, as for caraways (1), proceeding in the same way until they are ⅓ the required size. You must not use your hand for these as for caraways (1), as they are liable to break. Dry in the stove, then suspend the pearling cot; boil some clarified loaf sugar to large pearl, and fill the cot; put some of the prepared comfits in the pan, but not too many at a time, as it is difficult to get them to pearl alike. Keep the syrup at the boiling point; open the spigot of the cot so as to allow it to run in a very small stream or continued dropping; swing the pan backwards and forwards gently, and keep a stronger fire under the pan than otherwise. Be careful that the syrup runs so that it dries as soon as dropped, which causes the comfits to appear rough. If one cot full of sugar is not enough, put in more until they are the required size. When one lot is finished, put in sieves to dry, and proceed with another; but do not let them lie in the pan after you have finished shaking them. They will be whiter and better if partly pearled one day and finished the next. Use the best clarified sugar to finish.

Almond.—Sift Valencia almonds in a cane or wicker sieve, pick out any pieces of shell and any very small or large almonds, using those which are near of a size; take about 4 lb., put into the comfit-pan, and proceed as for caraways (1); or they may first have a coating of dissolved gum arabic; rub well about the pan with the hand, and give a dust of flour, then pour on a little syrup at small thread, work and dry well, give 3 or 4 more charges, and a charge of gum with a dust of flour. Proceed thus until they are ⅓ the required size, then dry for a day, and proceed and finish as for caraway comfits. For cheaper comfits, more gum and flour are used.

Colouring.—Put some of the comfits or nonpareils into the comfit-pan, shake or rub about until warm, add sufficient prepared liquid colour to give the desired tint; be careful not to make too wet, nor of too dark a colour; shake or rub well about, that they may be coloured equally; dry a little over the fire, put in sieves, and finish drying in the stove. Clean the pan for every separate colour.

Extracting the Acid from Candied Drops, etc.—Articles which have acid mixed with them are useless except to sell for broken pieces, as they cannot be boiled again unless the acid is extracted. The method of doing this is only returning to the first principle in the manufacture of sugar. When the juice is expressed from the sugar-canes, it contains a considerable quantity of acid, which must be destroyed before it will granulate into sugar. For this purpose, lime is employed, and has the desired effect; it will also in this case, but chalk or whiting is most generally used. First dissolve your acid sugar in water; when this is thoroughly accomplished, mix in a sufficient quantity of either of these alkaline powders to cause a strong effervescence; after it has subsided, pass through a flannel bag, according to the directions for clarifying sugar. The filtered syrup will be fit to use for any purpose, and may be boiled again to crack or caramel as well as if no acid had ever been mixed with it. Let the pan it is dissolved in be capable of containing as much again as there is in it.

Spinning.—Proficiency in this requires much practice, a good taste for design, and expertness in boiling, taking particular care to avoid graining. The moulds may be made either of copper or tin, slightly rubbed over with butter or oil. Boil clarified syrup to "caramel," taking care to keep the sides of the pan free from sugar. The moment it is at crack, add a little acid to "grease" it. When at caramel, dip the bottom of the pan into cold water, take out, and let cool a little; then dip a tablespoon in the sugar, holding the mould in your left hand, and from the spoon run the sugar over the mould, either inside or out, with the threads which flow from it, which may be either fine or coarse, according to the state of the sugar. If required very coarse, pass the hand over them 2 or 3 times; when hot, it flows in finer strings than when cooler. Form on the mould into a sort of trelliswork; loosen from the mould carefully, and let remain until quite cold before taking off, that it may retain its shape. When the sugar gets too cold to flow, put it beside the stove or fire.

Colouring Substances used in Sweetmeat Making.—White: finest starch (flour). Yellow: turmeric, saffron, safflower. Blue: indigo solution, litmus. Red: carmine, madder red, cochineal. Brown: caramel (burnt sugar), liquorice juice. Green: spinach juice, mixtures of the yellows and blues mentioned above. Mauve: violet, purple, heliotrope, etc., mixtures of the reds and blues mentioned above.

The foregoing may be considered as organic matters to a large extent, while the following are strictly chemical, being innocuous, aniline colours. These colours are largely used in continental manufactories of sweetmeats. The following are commercial names: *Reds*: Ponceau and Bordeaux red, fuchsin, acid fuchsin or rubin, roccellin, phloxin, eosin, erythrosin. *Blues*: aniline blue, alizarin blue, water blue, induline. *Yellow*: naphthol yellow, orange I or tropaeolin OOO, acid yellow R. *Green*: malachite green. *Violet*: methylviolet.

Flavouring and Thickening Ingredients used in Sugar Sweets, Chocolate, etc. *Saccharin.*—This is a sweetening ingredient used where occasion requires, but having the drawback that its bulk and weight do not add to the volume of the mixture being prepared. It is a preparation artificially constructed from the products of the distillation of coal—from coal tar as the more common expression is. It is soluble to a small extent in cold water, easily soluble in hot. For general purposes the quality used is about 400 times as sweet as sugar. It serves an excellent purpose in the preparation of delicacies for some invalids, as it is unaltered when passing through the human body. On this account it may be used for sweetening foods for those suffering from diabetes, corpulence, and certain stomach troubles that sugar has an ill effect upon. Pure saccharin is so sweet that its flavour can be discerned in a solution of 1 part to 70,000 parts of water.

Starch.—This, in some forms, is largely used in chocolate making, acting in a sense as an adulterant, yet having a beneficial general effect. The chief starches are: potato starch and potato flour, wheat starch and wheat flour, dextrin (starch heated to 205° C. to convert into starch gum and sugar), rice starch, arrowroot, chestnut meal, bean meal (this has to be sweetened with saccharin owing to the large proportion of albuminous substance and small amount of starch contained. The bean or vegetable flavour disappears, if this meal is slightly roasted).

Vanilla.—This is the fruit of a species of orchid. Although the essence —vanillin—has so largely superseded vanilla, yet the imports of the latter have actually increased. This may be due to the substance being used for other and new purposes. Vanilla can, of course, be obtained pure, but it is subject to adulteration, if it may be so termed, by admixture of pods of similar fruit of less flavouring value, also with pods which have been partly deprived of their essence. Both the latter are coloured and made to look like the true capsules.

Vanillin, if of good quality is obtained wholly from the vanilla fruit, but is also obtainable from certain sugars, from potato skins and from Siam benzoin. It may be obtained artificially from pine wood products, and during the last few years several means of producing vanillin artificially have been discovered. This substance is largely adulterated with the aromatic principles of other fragrant products. American "vanilla crystals" have been found to consist of vanillin and antifebrin, or vanillin, cumarin and benzoic acid. Cheaper qualities have been found to be devoid of vanillin, consisting only of cumarin, antifebrin and sugar.

In a work recently published, the financial advantage obtained by using vanillin instead of vanilla is estimated as 20 to 1. A kilo of vanilla and 25 grm. of vanillin, are equal in perfuming qualities, while this quantity of vanilla costs about 3*l.* to 3*l.* 5*s.*, and the vanillin 2*s.* 9*d.*

In using vanillin, it should be rubbed down with sugar, 50 grams of the former to 1 kilo of the latter, so as to reduce the vanillin to the necessary finely divided state. The process is to dissolve the 50 grams of vanillin in 250 grams of hot alcohol, and add this to the kilo of sugar which has been finely powdered. It is then put in a rotary comfit-pan and dried by moderately warm air. Vanillin, it may be mentioned, will keep well (even in the sugar if not allowed to get damp so as to ferment), whereas vanilla does not keep well.

Cinnamon.—There are at least 3 kinds of cinnamon, but in all the aromatic quality lies in the oil it contains. Caution should be observed, in purchasing, to have the bark and not to buy the ready-ground powder, as the latter is so easily adulterated. The grinding should be done by the purchaser to avoid this. Apart from adulteration, the powdered cinnamon can have some of its oil distilled off, and so be of less flavouring quality, without the purchaser readily noticing it.

Cloves.—This flavouring ingredient should be bought whole for the reasons just given. It is the oil in the cloves that provides the aromatic quality.

Nutmeg and Mace.—Both these owe their aromatic qualities to an oil they contain. As with cinnamon they should be bought whole and ground by the purchaser so as to avoid possible adulteration and deterioration.

Cardamoms.—These are a fruit, those from Malabar being about ½ in. in size, while those from Ceylon are some four times as large. In each case the fruit contains seeds, and these contain the aromatic principle.

Oils, etc.—The essential oils of the various fruits and seeds are now so easily obtained, and at so reasonable a cost, that they are being very widely used in place of the solid ingredient. The chief of these are oil of cinnamon, oil of cloves, oil of cardamoms, oil of nutmegs, oil of mace, and oil of coriander. To judge of the quantity required for flavouring experience is necessary, but if the oil is pure and of full strength it should be sufficient to find the amount of oil in the raw material, and use the prepared oil accordingly. Thus the essential oil in cinnamon bark is but one-hundredth of the whole, therefore 1 oz. of prepared oil should have the flavouring qualities of 100 oz. of ground bark. This, however, is but a theoretical reasoning, and trial with experience is needed. In using oils the best plan is to rub them down with sugar (as explained with vanillin), 1 part of oil dissolved in 9 of alcohol, this being added to the sugar and dried gently as explained; or the oil can be ground up direct with powdered sugar, in a mortar, 1 part of oil to 40 of sugar.

A good oil flavouring for chocolate is a solution of 15 grams of coriander oil with 85 grams of spirit.

Gum benzoin is a material largely used in chocolate manufacture, containing as it does vanillin and benzoic acid. The best comes from Sumatra. It is used as a varnish for chocolate and other confections, being dissolved in spirit (30 to 40 of gum to 100 of strong spirit). Bleached shellac may be added when desirable.

Peru balsam is used as a perfume. It is highly aromatic having a quality peculiar to itself in this respect. It is soluble in alcohol.

* * *

COOKING APPARATUS.

COOKING BY STEAM.

STEAM cooking boilers may be said to be of two kinds, viz., those that go at the back of a kitchen range fire, and which are suited for small requirements, and those that are independent and can be had in any size to meet any demand.

In the kitchens of good houses, establishments of some size, a small steam cooking plant is often put up. There are many things, fish, vegetables, hams, etc., that are cooked in a superior manner by steam, and the plant is put in on this account, and also to supplement the other cooking apparatus. Where convenient or desirable the kitchen range boiler is put to this service, and if the fire is of good size a very useful amount of steam can be got. If a steam boiler is put at the back of the range fire, there is, of course, no accommodation for the customary hot water boiler, but in a large house this can often be arranged as the demand for hot water is such that an independent boiler is required. It is seldom that a boiler behind the kitchen range will furnish an adequate supply of hot water for a really large house, and as an independent boiler has to be used for this, it can be easily arranged to put a steam boiler behind the range fire.

It is of very little use putting a steam boiler behind a range fire less than 10 inches wide, for a fire of a smaller size has comparatively no heat for constant steam making, remembering that the whole of the heat is not devoted to the boiler, nor much more than half of it. It is not worth while putting a boiler and all the fittings and connections for the trifling amount of work such a small fire and boiler could do.

It is best, in fact necessary, in all cases, not to attempt to supply the hot-water circulating apparatus from the same fire. It has been the practice to put *twin* boilers behind the fire, one of these heating the hot-water circulation, the other generating steam for cooking. Unless the fire was extravagantly wide for the size of range, this always meant two narrow, mean little boilers neither capable of doing more than about half the work a fair sized house requires of them, and the result was a failure. Further it could not be well arranged to put a separate flue and draft damper to each; consequently the fire acted on both equally. This meant heating both when only one was required, urging or checking both when only one needed it. It is a most unfortunate arrangement in point of efficacy and convenient working.

It should always be arranged to devote the fire wholly to the one steam boiler or do without it, unless by chance the range is a very large one for some reason, and the fire, say, 16 in. wide. It would not be desirable to put twin boilers to a less size fire than this, unless the work required of them should be very small. It becomes easily possible to use a steam boiler when two ranges exist, or, as more often happens, the hot-water circulation is from an independent heater. Or there are instances where the users of the range require but one oven, and then one boiler is put behind the fire, and the other at the unoccupied side.

The form that steam range boilers take is the "boot" shape, as Fig. 119, but it is much better to widen out the back, as Fig. 120, or adopt some other means of increasing the area of the water line, also increasing the capacity of the steam chamber above the water-line. It has been proved beyond doubt, by the writer and others, that although the heating surface may not be increased, the yield of steam is much superior from a boiler as Fig. 120 than from Fig. 119. Incidentally it may be mentioned that many designs of steam boilers for heating purposes appear to be deficient in water-line area and in steam room above the line; not that the boilers may be inefficient heaters, but that their efficiency would undoubtedly be improved by attention to this detail. Experiments with these comparatively small range boilers show that best results are had when the steam chamber above water-line has a cubic capacity of one-third of the whole interior of the boiler, or, in other words, one third the capacity of the space occupied by the water. This is assuming other conditions, generally, are correct.

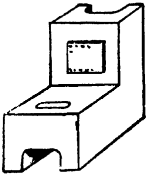
FIG. 119.

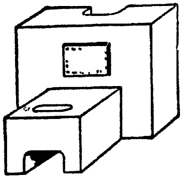
FIG. 120.

When it is possible the whole of the fittings are put on the boiler as in Fig. 121, this being a sectional elevation of the back part—the "leg" of the boiler. This is done when the leg of the boiler comes forward and is visible at the back of the range, but most ranges are constructed so that the leg has to be recessed behind the back coving plates, and is therefore out of sight. In this case a "hydraulic box," or feed cistern, is used, as in Fig. 122. The fittings are put on this, as of course they must come in sight somewhere.

Of the fittings, the water inlet valve may be considered the most important. This is a pillar valve, with balanced arm having a weight at one end and a stone float suspended at the other. The float is a piece of sandstone about 8 in. by 5 in. by 1½ in. thick. This answers excellently. It will be seen that a pipe is attached to the pillar inside the boiler so that the incoming water may be delivered near the bottom and not at the top. The valve is fed from the house supply, or the main, but in the former case it is necessary to see that the house cistern is sufficiently high above to afford the necessary pressure.

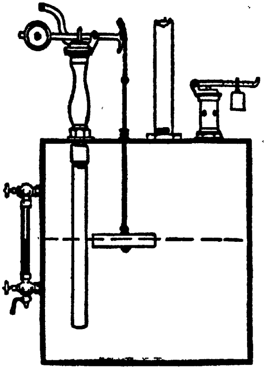

FIG. 121.

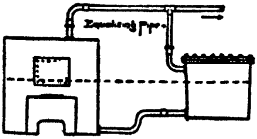

FIG. 122.

These boilers are worked at from 4 lb. to 10 lb. pressure, and if the water pressure does not exceed the steam pressure, the valve, when it opens, becomes a steam outlet instead of a water inlet. With steam at 10 lb. pressure, for instance, the cistern would require to be at least 25 ft. above the boiler, as the pressure of water in pipes is but 1 lb. for each 2 ft. 4 in. vertical height. If the cistern was only 20 ft. above, no water would enter the boiler when the valve opened and the steam was at 10 lb. gauge pressure.

Attempts are made to feed steam boilers with an ordinary open supply cistern and ball valve, trusting to a deep dip or "syphon" in the supply pipe to resist the back pressure of the steam. It is, however, a very poor arrangement, as the pressure must be kept down to about 1 lb., and the steam is then very wet for cooking.

Where there is but one range and one boiler to it, attempts are made to use this as a steam boiler and heat the needed supply of hot water by steam from it. This is usually a failure unless the fire be large and the boiler proportionately powerful and effective. If it could be arranged that the boiler furnished steam for cooking at certain hours and heated water at other times, then it would seem a good arrangement, for there is the disadvantage, in many cases, that a steam boiler is boiling away for no purpose when the cooking is done. As a rule the servants draw water from it for kitchen purposes when not cooking, but it would be better if its heat was turned into a tank.

If the noise is not objected to the most effective and economical plan of heating water is by free steam, with a tank and piping fitted up as in Fig. 123.

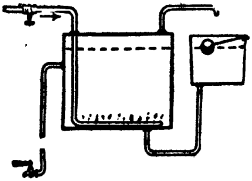

FIG. 123.

There should be a check-valve in the supply pipe, for, should steam cease while the stop valve is open some of the tank water will pass over by syphonage.

If free steam is not used, then recourse is had to a coil in the tank. This coil can have its condensation pipe, its exhaust, taken back to the boiler, so as to form a complete circuit and waste no water, or it can be discharged by a steam trap, or pass into a closed tank. It is of little use attempting to trap the exhaust with a deep dip unless the steam carries but a light pressure. With 7 lb. steam the dip would require to be about 18 ft. deep to be successful.

In making up this coil it is very necessary that it be placed tight on the bottom of the tank, otherwise the water at the bottom will not heat. In one instance a plumber had the correct quantities of piping given him for a coil which would boil the contents of a tank for tea and coffee-making. He fitted it up himself very well, but he put the coil quite 6 in. off the bottom of the tank. The result was that the water below the coil could rarely be got up to 100° F., and it was easy to see what a prejudicial effect this had in getting the water to boiling point above. The improvement was extremely marked when the coil was put on the bottom, all the difference between success and failure.

About the smallest steam cooking apparatus that is ever fitted up is illustrated in Fig. 124. This shows, in sectional elevation, the side boiler of a single-oven cooking range with connection for furnishing steam to a cooking-pot, or "kettle" as the vessel is called. To effect this the boiler, in the first place, must be an effective heating one. One with a neck at the top, as illustrated, is usually the most effective kind. From the small steam space above the water line a ½ in. or ⅝ in. pipe is taken to the kettle, which is placed on a low shelf or table near by.

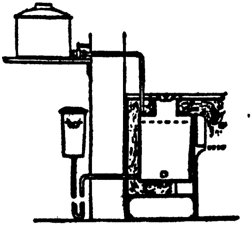

FIG. 124.

There is no condense pipe from the kettle, as a rule, for the amount of steam condensed is not large and the resulting water is emptied out when cooking is over.

The junction of the kettle and steam service is by the stop-cock shown. This has a coned male outlet which fits a coned female piece attached to the kettle. The kettle is merely pushed tight on to the cock when the food stuffs are in it and steam turned on. When the contents are cooked, the kettle is just drawn away and emptied in the usual manner.

Two essential details are, a proper lid for the boiler, and a sufficiently deep dip in the cold supply pipe. Ordinary loose boiler lids are not steam tight, nor heavy enough to make a pressure of 1 lb. to the square in. in the boiler. A brass lid is best, heavy enough for 1 lb. pressure, and this, with the rim it fits into, must be turned true to ensure a steam tight fit without jointing material or fastenings of any kind. To calculate the weight of lid, measure its area on the underside, and if it is 10 in. it should weigh 10 lb. A little less will do as a ½ lb. pressure is practically sufficient for this purpose. The higher the pressure the drier the steam.

The cold supply is fitted up in the same manner as the ordinary self-filling apparatus put to these boilers at other times. The only difference, if it can be called such, is in the depth of dip. Ordinarily a 6 in. dip is ample, but this will not do when steam is made. The depth of dip will depend on the weight of the lid. If 1 lb. pressure is decided on the dip must exceed 2 ft. 4 in., making it preferably 3 ft. deep. If the dip is insufficient then the steam pressure will force the water from the boiler back into the cistern, where it will overflow and cause trouble generally. It will leave the boiler temporarily empty, or nearly empty, which results in injury by the fire beating on the empty part.

It is very important that the dip be deep enough, as will be seen, for steam may be made at unexpected times, when no cooking is in progress. The lid acts as a safety valve, lifting and releasing steam when the pressure exceeds 1 lb., and provided, of course, that the dip is deep enough to prevent the pressure relieving itself that way.

When steam is not required the boiler supplies hot water, this being drawn from the tap in front, as usual. It serves all the customary purposes of an ordinary hot-water boiler at such times.

Whenever it is possible the best plan is to have an independent boiler for steam cooking, and let the range boiler provide the hot water as usual. Hot water is needed every day and all the day long, just as long as the range fire is kept alight, and cooks are now conversant with the management of ranges so as to afford the needed supply of hot water at all the hours that the demand comes.

The independent steam boiler then has its fire lighted as required. It may not be needed every day and seldom the whole of any day. In private residences, however large, the independent steam boiler has many idle hours and days, occasionally weeks. If it was a range boiler, it would be making steam at all these times uselessly, worse than uselessly in fact, for the boiling is violent and the discharge of steam an annoyance. The independent boiler is much more effective than the range boiler and this is an advantage.

In hotels, restaurants, and institutions, the independent boiler is necessary, as a range boiler is seldom sufficient. In such places, all vegetables, hams, puddings, etc., are cooked by steam, besides which there are cutting tables, hot plates and hot closets to be served, and, in most cases, the steam boiler also heats the water for the kitchen section besides supplying lavatory basins, etc.

Independent boilers for steam cooking are always of a plain vertical design, as Fig. 125, usually with cross-tubes as shown. The reason for its plainness is, that as the condense water is not returned to the boiler there is a considerable and constant change of water occurring, and this, in hard-water districts, creates a troublesome amount of lime deposit to appear. On this account, all such boilers, fed with hard-water, are of plain form, have the water-way carried down below the fire-bars, and doors are provided for the easy removal of the lime from this and all collecting points. As a rule steam-cooking boilers require to have the deposit cleaned out as often as range boilers which are in regular use for domestic hot water supply. In London this is about every six months.

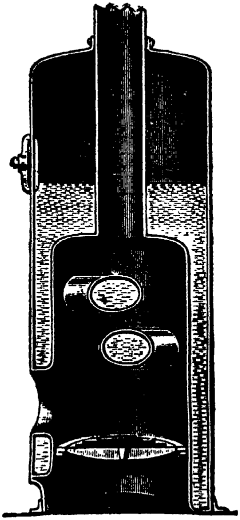

FIG. 125.

As to the capabilities of the various boilers a proper form of boot boiler in a kitchen range, with 10 in. fire, will work two kettles (tin cooking pots), while with an 11 in. fire, three kettles can be supplied. A 12 in. fire can have two kettles and a small pudding steamer, while a 14 in. fire (usually in a 6 ft. range) can have three kettles and a moderate sized cooking closet. With the latter boiler the steam might be got to 6 lb., if the water pressure allowed. When a range boiler is used for steam cooking, it should not be expected to also heat water by steam, unless the latter can be done at times when no cooking is on.

Where steam is regularly used for cooking some of the cooking vessels are often of the jacketed kind. These do not allow the steam to come directly to the foods being cooked, but receive it in a shell or jacket surrounding the cooking vessel proper. This is for boiling purposes only, and the fact is mentioned because such vessels require more steam, and it should be at 10 lb. pressure.

For restaurant work the independent boiler is used, and the usual smallest size is one horse-power. This size might be put to work a ham-closet, a pudding steamer, two or three vegetable pans, and a hot closet and cutting table. It would also heat the hot water required, if put to do this when the cooking work slackened off. Such a boiler would serve a moderate sized middle class restaurant, seating perhaps fifty people at the time. A fair-sized good-class restaurant needs about a three horse-power boiler and so on. (F. DYE.)

* * *

THE COOKING RANGE.

FAULTS AND CAUSES OF FAILURE.

IT is doubtful whether any other domestic appliance, taking average results, is complained of so much as the kitchen range, for out of, say one hundred ranges of various kinds, probably no more than a dozen are credited with being perfect in the way they do their work. They appear to work with varying degrees of efficiency, some burning everything that is put in the ovens, others working sluggishly, so that the cooking is very poorly done and unsatisfactory. Of ranges which manage to consume immoderate quantities of fuel, yet often fail to cook at all, everyone has heard. And the range which is eccentric in its behaviour, working well one day and failing the next (or *vice versâ*), is almost as familiar. If a range sometimes works well and regularly in regard to its ovens, then there is every chance of something being wrong with the boiler; and in touching on this subject (boilers), there is a wider range of possible faults than ever. It may be desirable to speak of the faults as being of three kinds. First, a failure, or a failing, with a range, something that has always existed in a regular way. Second, a fault that develops itself and stays, unless means are taken to remedy it. Third, troubles of the erratic kind, that come and go, and make it seem as if the range was really capable of displaying good or ill humour.

Taking the first character of trouble referred to, this can only be due to something wrong in the fixing. The trouble may be that the left-hand oven does not work as well as the right, and never has. It may be that the range has always worked sluggishly, not burning with so bright a fire, nor cooking so well, as some previously used range did, and so on. The only remedial measure is to discover the fault, and put it right. If one oven does better than the other—there being two to the range—it must be that the flues are not constructed alike, or those of the oven at fault may be throttled or choked. The first step is to examine the flues, and if they appear clear, then see if any brickwork overhangs the top outlet, preventing the free passage of draught, smoke, etc. It is not necessary that the outlets of the back flues, where they throw the smoke into the chimney, have no brickwork anywhere over them; but the brickwork, if there is any, must not come lower than 12 in. over the flue apertures, otherwise it will interfere with the draught.

When a man sets a range and makes the necessary flues round the ovens, he, of course, makes the flues precisely alike in general character and area, if there are two ovens to the range. Should he do otherwise, there is every possibility of the ovens differing in efficiency. This, however, is very unlikely. It must be remembered, however, that any shape and size of passage for the heat and smoke to pass round an oven does not make an efficient flue, and it is possible to lay down a rule in regard to this.

In the first place, certain phenomena connected with flame must be clearly understood. The ovens of all modern ranges rely upon flame being made to sweep round them to afford the required heat. If flame is absent we do not get real efficiency, any more than we do if we try to cook, in such a range, with a coke fire. Further than this, it is essential that the flame be brought into contact with the surfaces to be heated. Flame has a very pronounced tendency to avoid contact with surfaces, particularly those of a much lower temperature than itself, and this has to be guarded against. If flame does not have actual contact, then no serviceable degree of heat is felt, for flame radiates very little heat indeed. All the devices of our boiler-makers, not forgetting the multitubular boiler, aim at getting intimate flame contact; otherwise loss of fuel occurs.

Flame contact is easily had in the oven flues of a close-fire range by using care in bringing the flue surfaces sufficiently close together. With the flue over the top of an oven, for instance, we have to make it so that the flame fills it full, and is thus brought to have contact, not merely with the top oven plate, but with the cast hot plate over it, where vessels are required to boil. In other words, the flue over an oven (and this is the first flue that the flame passes through after leaving the fire-box), has to have the flame touching both the top and bottom surfaces, the upper one being the hot plate of the range, the lower one the top plate of the oven. After passing through this, the flame takes a descending course through a flue which passes down the outer side of the oven. From here it enters the flue, passing underneath the oven, joining the ascending flue at the back, which terminates in the chimney.

Although flame-contact is to be had by bringing the flue surfaces closer together, this must not be carried too far, or the passage will be choked and efficiency spoiled. Room must also be allowed for the narrowing of the flues that occurs by deposition of soot on the surfaces, for it is required that a range go at least a week without the flues having to be cleaned. The efficient sizes of these flues can be accepted as follows: That they are made the full depth (front to back) of the oven, as near as is possible. That with a 3 ft. range the first flue over the oven top be 2¼ in. between surfaces; the next flue down the outer side 2 in.; the flue under the bottom 2¼ in. This latter flue is the one where soot accumulates, it being carried there by the draught. These sizes are strictly right for a 3 ft. range of any kind that has to be set in brickwork (with iron flue ranges the flues are all provided and fitted by the makers). With larger-sized ranges these three flues may be increased in size by ¼ in. to 5/16 in.

(not more) for every foot increase in the width of the range. Thus, a 5 ft. range would have the oven flues (one or two ovens), top 2⅛ in., side 2¼ in., bottom 2¾ in.

These sizes given will be found noticeably smaller than it is customary to make them; but they are correct and will give the best results. They are not small enough to choke the passage of flame, smoke, and products, yet not large enough to allow the flames to float between the surfaces, and not have contact as they are inclined to do. It is almost unnecessary to point out that the deflecting-plate or midfeather which is placed in the bottom flue (extending from the back about half-way to the front) must always be put. Its purpose, as every range-fixer knows, is to keep the flame well spread around the oven surfaces. If it did not exist, the flame would hug the back part of the flues, for it seeks the shortest way to the back outlet as a matter of course. As to the size of the back flues, those extending from the bottom of the range, and forming continuations, or outlets, to the oven flues, these must bear a recognised proportion to the oven flues. Their area should be that of the down flue on the outer side of the oven. Supposing this latter had an area 16 in. by 2 in. = 32 sq. in., then the back flue should be of equal area; not a broad flat one, as 16 in. by 2 in. would be, but, say, 8 in. wide by 4 in. deep. This latter forms a rather flat flue, which the writer favours; but if the dampers sent with the range are not broad enough, the flue can be more square, say, 6 in. by 6 in., or a trifle under.

If flues are constructed carefully and to a recognised scale of proportions, the range *must* work well. Great care, however, is necessary to see the flues are regular in size everywhere. If choked at any point the effect is the same as making them too small throughout. A 4 in. pipe, whatever its length, would not yield its fullest if it was pinched in to the size of a 2 in. pipe at any point. This is the same with oven flues, and a checked flue brings many troubles in its train. On the other hand, too large a size of flues admits of a roaring fire being kept to do but little work.

To complete the "failures from the first," reference must be made to the unfortunate want of knowledge many workmen (who freely undertake to fix ranges) have as to what a range depends on for efficiency. Every range—the exception being about one in a hundred—that fails to work properly when newly fixed or refixed, owes any failure that may be experienced to the way in which it is set. It is of no avail the man blaming the range, for, it may be repeated, no maker sends out ranges that will not work if they are set properly, and the setting of any range, even choosing the most complicated or notoriously troublesome, is work that any man can do if he knows what a range depends on for efficiency.

Flame-contact has been alluded to; but to get that we must have the very necessary draught. Every modern range depends upon the draught created by the chimney, causing the flame and heated products to sweep round the oven or other flues, and this must be done thoroughly to insure success. An ordinary 5 ft. range working with a normal draught will have tongues of flame 4 ft. and 5 ft. long, extending from the fire across the top and down the side of the oven, only assuming the dying red tinge in the bottom flue. This is due to the draught, for the flame certainly has no inclination to travel in directions so very contrary to what it would do naturally. Furthermore, we should never get such effective flames from so small a fire without the aid of this swift air current. Consequently, the draught is plainly the life of the range, and a range fixer must clearly understand it, and know its management. If he does not, the range stands every chance of being made a feeble, or dead thing, in his hands.

The draught, which is such a noticeable feature in a close-fire kitchen-range, and which, as stated, is quite the life of it, is induced in the chimney. A perfectly new chimney has no effective draught, though a feeble up-current is manifested sometimes, if the interior of the house is a degree or two warmer than the outside. On lighting a fire at the foot of a new chimney, and waiting until the heated products manage to ascend and warm the interior brickwork, a draught sets up of a very effective character. When the brickwork is thoroughly dry and warm, the up-current (if the chimney does not sometimes suffer with down-blow) will be strong and become permanent, even with grates in which no fire is lighted during the summer months. The cause of the draught is the warmth imparted to the air in the chimney by the heated brickwork.

Air when heated is lighter than cold air, and is readily displaced by the superior weight of the latter. Consequently the warmed air in a chimney is constantly being thrust upwards, and the cold air which takes its place instantly receives warmth and has to follow. It is a regular and swift displacement of warmed air by that which is cold; but this latter is instantly warmed a little, and is displaced in its turn. This is when a chimney has no fire at its base. When there is a fire, the action is greatly intensified, for the air passing into the chimney has to pass over a hot fire; it has to mingle with heated products of combustion, and these latter go to increase the heat of the brickwork. The consequence of this is a draught of a very powerful character, capable of doing very efficient work. In the ordinary brick kitchen chimney, averaging 30 ft. to 40 ft. in height, the draught will easily make the fire roar, and burn like a furnace, if not restrained. When a kitchen is at the top of a building (as in some business houses), the comparatively short chimney is still quite able to work a large range well and efficiently.

The secret of successful range-fixing in regard to management of the draught is to do the work so that all the air which enters the chimney first passes through the fire. This means that the draught, the up-current in the chimney, has its ingress wholly through the front and bottom bars of the range firebox. The range must be fixed air-tight; there must be no openings, nor crevices even, around or about the range. No apertures in the chimney. No other flues leading into the chimney, unless it be a copper flue, and this is only admissible provided it has a damper to tightly shut it off when the copper fire is not alight. By these precautions we are practically putting steam to the engine, no waste of power, and if we have too much, there are the means of controlling it. A range fixed with this care—the chimney having a normal draught and the flues constructed with due regard to size, as already explained—will work in a manner that cannot fail to please. The full efficiency of the draught at command will enable the cook to have a quick response to the opening of the dampers. Opening a damper in such a case means an instant and swift rush of flame around the oven, with almost as rapid results inside it. The trouble is that cooks will not always regulate dampers as they should do, and as it would be to their decided benefit to do; but this will be alluded to more fully directly.

The second class of trouble given—that of a range developing faults which remain with it until remedied, is a result of wear and tear usually. If a range starts out well, it very rarely develops a fault for a considerable time which is not the fault of the cook—such as dirty flues, mismanagement, etc. After time, however, trouble comes, not by the mere wearing out of bottom bars, fire-cheeks, etc., as these do not interfere with efficiency unless allowed to get so bad as to prevent the fire burning properly. It is the setting that gets into bad condition, and, this being an invisible part of the structure, its real state cannot be seen. It is, therefore, the usual thing for a man to try all sorts of things in hope of improving matters; but it is rarely successful unless he adopts the only real remedy: to reset the range. If, after a few years (governed by the way the range is used; also by the way in which it was first fixed, and the quality of materials used), it appears there is something wrong—and this is shown by the immoderate stoking required to get an effective heat in the oven—the setting will be at fault beyond doubt. A man is called in, and he, by diligent search, finds a certain part broken away which allows a large proportion of the draught, with its flame and heat, to escape up the chimney without doing any work. He thereupon stops this opening, and it may wholly remedy the trouble; but it will not be for long, as that faulty part is an indication that all other parts are approaching a similar condition, and the complete resetting is only delayed a little.

It is only ranges with brickwork flues that these remarks apply to. Ranges with iron flues (and all makes can be had with iron flues now), when once set properly, which is usually a more simple task, rarely, if ever, want resetting. Brickwork flues are not lasting, by any means, however well they may be constructed. The heat, in the first place, makes a severance between the iron and the brickwork, for, on first heating, the ironwork expands, and makes room for itself, and, on its subsequent contraction, it parts company with its surroundings, as the two different materials cannot be made to unite soundly, and move with one another. From that time forward the brickwork gradually deteriorates with the heat, the joints between metal and bricks becoming less sound, the cement-work crumbling, and, eventually, as almost everyone knows, the range behaves so badly that resetting must be resorted to. If the ironwork of the range is in good condition, the resetting will make the results equal to what they were when the range was newly fixed; but in course of time the same experience must be gone through again.

The third character of trouble, eccentric results, may be set down to the cook or the chimney. If the chimney is at fault, it is that it suffers with down-blow. Down-blow is a trouble only manifested when the wind is in certain quarters, so that the range may work well one day and fail the next; or the change may take place in even shorter time than this. Down-blow is usually evidenced by smoke, and perhaps flame, being impelled from the fire into the kitchen, and then there is no mistaking the nature of the trouble. Sometimes, however—and it is governed by how the chimney terminates at top—the down-blow is of a feeble character, just sufficient, when it occurs, to make the range fire dull, and disinclined to "draw." In other words, it is scarcely a down-blow, but an impeded or checked up-draught. In such a case, the results are much like those obtained by careless attention, or dirty flues; but this is easily settled by a brief examination. Nothing but down-blow can cause irregular results except faults directly traceable to the cook.

As to the things a cook may do to cause a range to work in an erratic manner, the number is very great, and something novel in this way is constantly occurring. The fact is, the close-fire kitchen range, whatever make it may be, seems more than the average cook can understand. Every credit must be given to the many clever cooks who understand the management of a range thoroughly; but still the majority of them cannot grasp the principle rightly. It is not to be wondered at, perhaps; for a good many men, who profess to be range-fixers, are little better in this respect. The close-fire range is distinctly mechanical, and as most cooks obtain their knowledge of how to work it by picking up the information from other cooks, and from their own ideas as to how it should be done, many wrong impressions must be not only created but firmly believed in. The use of the close-fire range should be a feature whenever cookery or domestic economy is taught, and it is not a subject that should be passed over with just a few brief remarks; nothing will bear demonstration more profitably.

As to what a cook may do to cause erratic results; she may, after cleaning the flues, leave one of the flue doors off. Those beneath the oven doors are often forgotten, being out of sight; and it is by no means a rare thing for a small flue door to find its way into the dust-bin. She may leave the damper of the copper open when no fire is alight beneath the copper. She may have failed to clean the flues. This is a common thing familiar to everyone; but sometimes it is only one piece of flue overlooked, which is almost as bad as overlooking them all. Sometimes it is the door in the covering-in plate opened for some reason, and this checks the range at once.

It is not necessary to go into these details further, for what it is intended to show is that a range has no power to act in an irregular way of itself. Sometimes a cook, in the most annoying way imaginable, will say that the range is the whole cause of erratic results; but it cannot possibly be. It is either the cook, or the effect the wind has on the chimney, as explained.

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COPYING.

(*See also* CAMERA OBSCURA, DRAWING, ENGRAVING, ETCHING, STEREOTYPING, ETC.)

THIS article deals with the various processes employed in obtaining copies or impressions of printed and written matter, such as letters, drawings, etc. The subject may be divided into chemical (including photographic) and mechanical methods, copying pencils, and transferring.

Chemical methods.—(1) *Blue prints* (cyanotype or ferro-prussiate paper). The paper used for this purpose is prepared by covering one side of the sheet with solutions of red prussiate of potash (ferrocyanide of potassium) and peroxide of iron; under the influence of light, i. e. under the white portions of the drawing to be copied, the ferric compound is reduced to the state of a ferrous salt, which gives with the red prussiate of potash an intense blue coloration, analogous to prussian blue. This coloration is not produced in the portions of the sensitive paper protected from the light by the black lines of the drawing to be copied, and on washing the print the design appears in white lines on a blue ground. The formula for preparing the sensitive paper is as follows: Dissolve 10 dr. red prussiate of potash (ferrocyanide) in 4 oz. water; dissolve separately 15 dr. ammonio-citrate of iron in 4 oz. water; filter the 2 solutions through ordinary filtering paper, and mix. Filter again into a large flat dish, and float each sheet of paper to be sensitised for 2 minutes on the surface of the liquid, without allowing any of this to run over the back of the paper. Hang up the sheets in a dark place to dry, and keep from light and dampness until used. They will retain sensitiveness for a long time. The paper being ready, the copy is easily made. Procure either a heavy sheet of plate glass, or a photographer's printing frame, and lay the drawing to be copied with the face against the glass; on the back of the drawing lay the prepared side of the sensitive paper, place upon it a piece of thick felt, and replace the cover of the printing frame, or in some other way press the felt and papers firmly against the glass. Expose, glass side up, to sunshine or diffused daylight, for a time, varying with the intensity of the light and the thickness of the paper bearing the original drawing, from minutes to hours. It is better to give too much than too little exposure, as the colour of a dark impression can be reduced by long washing, while a feeble print is irremediably spoiled. By leaving a bit of the sensitive paper projecting from under the glass, the progress of the coloration can be observed. When the exposure has continued long enough, the frame is opened and the sensitive sheet is withdrawn and thrown into a pan of water, to be replaced immediately by another, if several copies are desired, so that the exposure of the second may be in progress, while the first is being washed and fixed. The water dissolves out the excess of the reagents used in the preparation of the paper, and after several washings with fresh water the print loses its sensitiveness and becomes permanent. It is advantageous, after several washings with water, to pass over the wet surface a weak solution of chlorine or of hydrochloric acid, 3 or 4 parts acid to 100 of water, which gives brilliancy and solidity to the blue tint, and prevents it from being washed out by long soaking. This should be followed by 2 or 3 rinsings with fresh water, and the print may then be hung up to dry, or placed between sheets of blotting-paper. (2) First solution: red prussiate of potash, 120 gr.; water, 2 oz. Second solution: ammonio-citrate of iron, 2 oz.; water, 140 gr. The solutions should be made separately, and, when dissolved, mixed and filtered; then pour it into a dish and float plain photographic paper on it for 3 or 4 minutes. When the paper is dried, it will keep for months. Print in the sun for 8 to 10 minutes; then simply wash the paper under the tap with running water. The result will be a strong blue picture on a white ground. The addition of a little gum arabic water to the above solution, when made, will render the colour of the picture richer and the whites purer. (3) Make a 25 per cent. solution of ammonium ferrocitrate, also a 25 per cent. solution of potassium ferricyanide. Mix in equal parts and spread with a broad brush, soft sponge or a ball of cotton wool, on one side of any good quality white paper. This gives white lines on a blue ground. (4) It is necessary to make two solutions and these should be kept separate until wanted for use, then they are mixed equally. The proportions are: first solution, 1 oz. citrate of iron and ammonia to 4 oz. water; second solution, 1 oz. potassium ferricyanide to 4 oz. water. Sensitising the paper with these solutions must be done by gas light. See that the solution is not put on in streaks. (5) For the two sensitising solutions make one of 400 gr. of ammonio-ferric citrate to 4 oz. water; the other 280 gr. ferricyanide of potassium to 4 oz. water. Use equal parts when required.

(6) Below is a formula used with excellent results:—

Solution No. 1.—35 grammes (539 gr.) of ferricyanide of potassium dissolved in 230 cubic centimetres (8 oz.) of distilled water.

Solution No 2.—53 grammes (816 gr.) of citrate of iron and ammonia dissolved in 230 cubic centimetres (8 oz.) of distilled water. These solutions must be kept separate.

When ready to prepare the paper, mix equal parts of Nos. 1 and 2 and apply to the paper either with sponge or soft cloth, and hang up to dry. These operations must be conducted in a dark room. As soon as the paper is dry, place under negative or tracing, and expose to direct sunlight. After printing, place in water and wash thoroughly.

(7) *White Lines on Blue Ground.*—The ordinary blue-print, with white lines on a blue ground, the simplicity of which has led to its adoption in many offices, has the inconvenience of giving a copy in white lines on blue ground, which fatigues the eye in some cases, while the application of other colours is impracticable. By repeating and reversing the process, copying the white line print first obtained on another sensitive sheet, a positive picture, representing the black lines of the original by blue lines on white ground, can be obtained; or the same result may be reached by a different mode of treating the sensitive paper. This latter may also be made by brushing it over with a solution of ferric oxalate (10 gr. to the oz.); the ferric oxalate is prepared by saturating a hot aqueous solution of oxalic acid with ferric oxide. A better sensitising solution may be made by mixing 437 gr. ammonium oxalate, 386 gr. oxalic acid, and 6 oz. water, heating to boiling-point, and stirring in as much hydrated peroxide of iron as it will dissolve.

(8) Pellet's process for blue lines on a white ground, requires the paper to be first coated with boiled starch, thus acting as a size to prevent the paper absorbing the sensitising solution. The latter consists of these ingredients in parts by weight, chloride of iron 2; citric acid 1; dissolved in 20 parts of water. In printing, which is fairly rapid, it is difficult to see when the exposure is sufficient, and the common plan is to have an extra little tracing and piece of sensitised paper, so that pieces of the latter can be torn off at intervals and tested. When the print is ready it is developed with yellow prussiate of potash dissolved in 3 times its weight of water. The print is first washed in water, then in very dilute hydrochloric acid, and lastly in water again.

(9) Several varieties of paper are sold, which have the property of giving a positive image. The mode of preparation is nearly the same for all; 3 solutions, 1 of 60 oz. gum arabic in 300 of water; 1 of 40 oz. ammoniacal citrate of iron in 80 of water; 1 of 25 oz. perchloride of iron in 50 of water, are allowed to settle until clear, then decanted, mixed and poured into a shallow dish, the sheets being floated on the surface as before, and hung up to dry. The solution soon becomes turbid, and must be used immediately, but the paper once dry is not subject to change unless exposed to light or moisture. The reactions involved in the printing process are more complex than in the first process, but present no particular difficulty. Under the influence of light and of the organic acid (citric), the perchloride of iron is reduced to protochloride, and, on being subjected to the action of ferrocyanide of potassium, the portions not reduced by the action of the light, that is, the lines corresponding to the black lines of the original drawing, alone exhibit the blue coloration. The gum plays also an important part in the process by becoming less soluble in the parts exposed to light, so as to repel in those portions the ferrocyanide solution. The mode of printing is exactly the same as before, but the paper is more sensitive, and the exposure varies from a few seconds in sunshine to 15 or 20 minutes in the shade. The exact period must be tested by exposing at the same time a slip of the sensitive paper under a piece of paper similar to that on which the original drawing is executed, and ruled with fine lines, so that bits can be torn off at intervals, and tested in the developing bath of ferrocyanide of potassium. If the exposure is incomplete, the paper will become blue all over in the ferrocyanide bath; if it has been too prolonged, no blue whatever will make its appearance, but the paper will remain white; if it is just long enough, the lines alone will be developed in blue on a white ground. During the test of the trial bits, the printing frame should be covered with an opaque

screen to prevent the exposure from proceeding further. After the exact point is reached, the print is removed from the frame and floated for a few moments on a bath of saturated solution of ferrocyanide of potassium, about 1 oz. of the solid crystals to 4 of water. On raising it, the design will be seen in dark blue lines on white ground. It is necessary to prevent the liquid from flowing over the back of the paper, which it would cover with a blue stain, and to prevent this the edges of the print are turned up all round. On lifting a corner, the progress of the development may be watched. As soon as the lines are sufficiently dark, or blue specks begin to show themselves in the white parts, the process must be immediately arrested by placing the sheet on a bath of pure water. If, as often happens, a blue tint then begins to spread all over the paper, it may be immersed in a mixture of 3 parts sulphuric or 8 of hydrochloric acid, to 100 of water. After leaving it in this acidulated liquid for 10 or 15 minutes, the design will seem to clear, and the sheet may then be rinsed in a large basin of water, or under a faucet furnished with a sprinkling nozzle, and a soft brush used to clear away any remaining clouds of blue; and finally, the paper hung up to dry. The ferrocyanide bath is not subject to change, and may be used to the last drop. If it begins to crystallise by evaporation, a few drops of water may be added. The specks of blue which are formed in this bath, if not removed by the subsequent washings, may be taken out at any time by touching them with a weak solution of carbonate of soda or potash. The prints may be coloured in the usual way.

(10) *Colouring or Alterations to Blue Prints.*—(*a*) A strong solution of ordinary washing soda will, by removing the blue, make white lines or other marks on blue prints. The writing of names, titles, or necessary alterations can be done in this way. The same applies if colours are to be filled in, as otherwise colours do not show effectively on a blue ground. The colours are merely mixed with soda solution to effect this. (*b*) *The most satisfactory marking ink for blue prints is the red soda.* This consists simply of a red ink, in which a little gum arabic and enough soda has been dissolved to decompose the blue colouring matter of the print. The relative amount of each is usually determined by trial. Red ink alone does not show much better on a blue print than black ink. The action of the soda solution alone is to decompose the blue matter of the print and leave the white paper exposed. This "white paper" is coloured at the same time to any colour desired, if the proper colouring matter be added to the clear soda solution. Diamond dyes answer admirably for this purpose. The gum arabic solution is added to thicken the soda solution, to prevent it from flowing too freely from the pen and spreading on the paper which it is otherwise liable to do. Caustic soda is the best for the purpose; ordinary washing soda, however, will answer. A red ink thus prepared makes a bright contrast with the blue background of the print, and looks well. Any small alteration of a drawing may be made without erasing the original lines; the drawing is easily read, because the red lines are so prominent.

(11) *Making Blue and other Prints Water-Proof.*—When prints have to be carried about and referred to in all weathers it is a great saving of annoyance, if they are water-proof. The following is a simple and inexpensive plan. Have several pieces of absorbent cloth, and immerse these in melted paraffin wax; take them out and when they are cool they are ready for use. First spread one of the prepared cloths on a smooth surface, place the dry print on it with a second cloth on top, and iron the same with a moderately hot flat-iron. The paper immediately absorbs paraffin until saturated, and becomes translucent and highly waterproof. The lines of the print are intensified by the process,

and there is no shrinking or distorsion. As the wax is used from the cloths, more can be added by melting small pieces directly under the hot iron. By immersing the print in a bath of melted paraffin the process is hastened, but the ironing is necessary to remove the surplus wax from the surface, unless the paper is to be directly exposed to the weather and not to be handled. This process was originally applied to blue-prints to be carried by the Engineer corps in wet weather.

(12) *Black Lines on a White Ground.*—Prints with blue lines on white ground can usually have the lines made black by immersing them first in a solution of common potash, 1 oz. in 25 oz. of water, and afterwards in a solution of tannin, 1 oz. in 20 oz. of water.

(13) Colas's method of printing black lines on white, direct, is as follows: make a sensitising solution of 2 oz. tartaric acid, 4 oz. perchloride of iron, 2 oz. persulphate of zinc, 2 oz. gelatine and 60 oz. water. Coat the paper with this and it will have a greenish tint, but this colour disappears with light. Developing is done by putting the print in a solution of water 25 oz., methylated alcohol 5 oz., and gallic acid ½ oz. This will bring the lines up a good black in about 3 minutes. Finally wash for ½ hour in running water.

(14) Sensitising solution for black lines on white ground (Shawcross and Thompson), gelatine 1500 grm., ferrous sulphate 600 grm., sodium chloride 940 grm., tartaric acid 188 grm., ferrous chloride 1500 grm., water 11 litres. The paper after being sensitised is lightly gone over with powdered gallic acid and tannic acid and the effect of this is, that these two substances being present, development is completed—effected in fact—with plain water.

(15) Joltrain's. Black lines on white ground. The paper is immersed in the following solution: 25 oz. gum, 3 oz. chloride of sodium, 10 oz. perchloride of iron (45° B.), 5 oz. sulphate of iron, 4 oz. tartaric acid, 47 oz. water. The developing bath is a solution of red or yellow prussiate of potash, neutral, alkaline, or acid. After being exposed, the positive is dipped in this bath, and the parts which did not receive the light take a dark green colour; the other parts do not change. It is then washed with water in order to remove the excess of prussiate, and dipped in a bath containing acetic, hydrochloric, or sulphuric acid, when all the substances which could affect the whiteness of the paper are removed. The lines have now an indigo black colour. Wash in water, and dry.

(16) A black process, which will compete for favour with the above blue process, is given in the *Photocopie* of A. Fisch. The process is simple, and inexpensive, while the prints are ink-black, and are made from drawings or positives and negatives. We owe this process to Poitevin, but it has been slightly improved.

Sensitising Solution.—Dissolve separately:—

1. Gum arabic . .	0	13 dr.
Water . . .	17 oz.	0
2. Tartaric acid . .	0	13 dr.
Water . . .	6 oz.	6 dr.
3. Persulphite of iron	0	8 dr.
Water . . .	6 oz.	6 dr.

The third solution is poured into the second, well agitated, and then these two solutions united are added to the first, continually stirring. When the mixture is complete, add slowly, still stirring, 100 c.c. (3 fl. oz. 3 dr.) of liquid acid perchloride of iron at 45° Baumé. Filter into a bottle and keep away from the light. It keeps well for a very long time.

Sensitising the Paper.—Here especially it becomes necessary to select a paper that is very strong, well sized, and as little porous as possible. By means of a large brush or sponge apply the sensitising liquid very equally in very thin and smooth coats; then dry as rapidly as possible with heat without exceeding, however, a temperature of 55° C. (131° F.). The paper should dry in obscurity, and be kept away from light and dampness; notwithstanding all these precautions it does not keep well long, and if it is desired to act with some certainty it is better to have a stock to last only a fortnight. Freshly prepared it is better than a few days afterwards. It should be of a yellow colour.

Printing.—The tracing, made with very black ink, is placed in the printing frame, the drawing in direct contact with the plate; then place over it the sensitised paper, the prepared side in contact with the back of the tracing. There is no necessity to make use of photometric bands as the progress of insolation is sufficiently seen on the sensitised paper during the exposure. From yellow that it was it should become perfectly white in the clear portions, that is to say, upon which there is no drawing of the transfer or positive that is to be copied; this is ascertained by raising from time to time the shutter of the frame. The exposure lasts 10–12 minutes in the sun; in summer less, in winter more. When the exposure is ended, remove the print from the frame, and it should show a yellow drawing upon a white ground. If in the sensitising bath a few cubic centimetres of a rather highly concentrated solution of sulphocyanide of potassium have been added, this bath becomes blood-red and colours the paper the same; in this case the print also whitens during exposure, but then the image, instead of being yellow, is red on a white ground. This substance, however, is, if we may so speak inert, or without any other action; it is very fugitive, and even disappears in a short time in obscurity; it has no other use, therefore, than to render the drawing or the image more visible after exposure.

Developing the Prints.—When the print has been sufficiently exposed it is taken from the pressure-frame and floated for a minute in the following solution, so that the side upon which is the image should alone be in contact with the surface of the liquid, avoiding air bubbles between the two surfaces. Otherwise defects would be found in the print; to ascertain this, raise in succession the four corners. The developing bath is composed as follows:—

Gallic acid (or tannin) .	31–46 gr.
Oxalic acid	1¼ gr.
Water	34 oz.

In this bath the orange yellow or red lines are changed into gallate or tannate of iron, and form, consequently a veritable black writing ink, as permanent as it. The print is then plunged into ordinary water, well rinsed, dried, and the print is now finished. The violet-black lines become darker in drying, but fortunately the ground which appears of a pure white, often acquires, in drying, a light violet tint. For prints with half tones this is of no importance; but for the reproduction of plans, for example, it is very objectionable. By this process we have the satisfaction of obtaining a drawing in black lines similar to the original, and in most cases this is sufficient.

(17) *Printing Blue or Other Prints of Tracings.*—This is usually done in daylight, printing frames like those for photographic purposes being used, but much larger and so secured at the back as to give a good pressure at all points. These frames are made as large as 10 ft. long. As a rule the frames have a glass front, but attempts have been made to do without the glass—and sometimes without the frames—by arranging to secure the tracing and sensitised paper on a thin board on metal sheet, which is then bent to a slight curve to stretch the papers tight. Such appliances are cheap and light, but do not appear to be used much. Of late special means have been devised to print after dark. A glass cylinder is arranged in an upright position, and the tracing and sensitised paper are placed against the outside of this tightly (by means of an outer cover), then an electric arc-light is turned on inside the cylinder, and with

so powerful a light, the printing is soon effected. By arranging the papers cylindrically around the light, the result is uniform and no waste of light occurs. The time taken in printing in daylight is very variable, ranging from a matter of minutes to an hour or two. Printing blue prints is complete when the paper, where the light has affected it, is a greenish blue, while the lines or parts where the light has not affected, are of a yellowish tint. When the print has reached this condition it is only necessary to take it out, lay it in a pan or tray, and turn water on to it (a hose or a tap). A weak print is sometimes improved by soaking and a very little dilute hydrochloric acid in the last washing water is beneficial at all times.

(18) Copies of drawings or designs in black and white may be produced upon paper and linen by giving the surface of the latter two coatings of: 217 gr. gum arabic, 70 gr. citric acid, 135 gr. iron chloride, ¼ pint water. The prepared material is printed under the drawing, and then immersed in a bath of yellow prussiate of potash, or of nitrate of silver, the picture thus developed being afterward put in water slightly acidified with sulphuric or hydrochloric acid.

(19) Benneden states that paper, prepared as follows, costs but ⅙ as much as the ordinary chloride of silver paper, is as well adapted to the multiplication of drawings, and is simpler in its manipulation. A solution of bichromate of potash and albumen or gum, to which carbon, or some pigment of any desired shade, has been added, is brushed, as uniformly as possible, upon well-sized paper by lamplight, and the paper is dried in the dark. The drawing, executed on fine transparent paper (or an engraving, or wood-cut, etc.), is then placed beneath a flat glass upon the prepared paper, and exposed to the light for a length of time dependent upon the intensity of the light. The drawing is removed from the paper by lamplight, and after washing the latter with water, a negative of the drawing remains, since the portions of the coating acted on by the light become insoluble in water. From such a negative, any number of positives can be taken in the same way.

(20) A process similar to autoscopy. The pad is prepared with glue, glycerine, and water, in the same manner as for the well-known hectograph, see (28) and (29), but with a larger proportion of glue. For writing or drawing, a concentrated solution of alum is used, coloured with a little aniline to render the writing visible. Before using, the pad is damped by means of a wet sponge, and the moisture is permitted to remain a few minutes. The writing may now be applied, and upon removing it, after a short time, the lines will be transferred to the pad. A small quantity of printers' ink is applied with a rubber roller, and will be taken up by the etched lines only. An impression is obtained by pressing moistened paper over the lines with the palm of the hand. The pad must be inked for each copy, but a great number may be made from the same etching or transfer.

(21) Paper prepared so that a brass pointer leaves a black mark on it. Dissolve ¼ oz. pure sodium sulphide and ½ oz. sodium hyposulphite in 1 qt. rain water; filter the solution, and with it uniformly moisten the surface of the paper; then dry the latter under pressure between clean blotting paper.

(22) Tilhet's process. The paper upon which the design is to be reproduced, in order to prepare a negative copy, is first passed through a bath composed of 30 oz. white soap, 30 oz. alum, 40 oz. Flanders glue, 10 oz. white of eggs or albumen beaten up, 2 oz. glacial acetic acid, 10 oz. alcohol at 60°, 500 oz. water. The paper, after having been removed from this bath, is passed through a second bath composed of 50 oz. burnt umber, ground in alcohol, 20 oz. black pigment, 10 oz. Flanders glue, 500 oz. water, 10 oz. bichromate of potash. The paper having been thus treated,

must be kept when dry in a dark place. In order to prepare positive paper for the prints, a bath is used similar to the last, but without the umber, for which black pigment is substituted. To obtain coloured proofs instead of black ones, the black pigment is replaced by a pigment of any desired colour. To prepare the copies, the design or drawing is placed in an ordinary photographic printing-frame, the back of the design being next to the glass, and a sheet of negative paper prepared in the way first described is placed in contact with it. The frame is then exposed to light, 2 minutes' exposure being sufficient in good weather. The sensitive paper is then removed from the frame in a dark place and is placed in water, when the design becomes visible in white, and the paper is allowed to dry. In order to obtain positive pictures from the negative thus prepared, the latter is placed in the printing-frame with a sheet of the positive paper prepared in the manner above described in contact with it, and after exposure to light for a sufficient time (about 2 minutes), the positive paper is removed in a dark place, and is plunged into water, which removes the part of the pigment which has not been affected by the light, without its being necessary to touch it. Any number of copies of the design or drawing may be produced upon any kind of paper, and in any colour or colours. The proportions of the different materials used to prepare the baths may be varied to suit circumstances, such as the weather, and the character of the design or of the paper.

(23) Zuccato's "papyrograph." A sheet of fine paper is saturated with a resinous varnish, and dried. On it, writing is made with an ink consisting of a strong solution of caustic soda, slightly coloured in order to be more obvious to the eye. The soda immediately attacks the resinous preparation of the paper, converting it into a soap. The sheet is floated on water, written side upwards; the water soon penetrates the softened parts, making the written lines stand up in bold relief as ridges of fluid. The paper is removed from the surface of the water, and pressed between folds of blotting-paper, after which it is once more floated on the surface of the water, and again blotted off, in order to remove the remainder of the resin soap. The sheet thus prepared forms a stencil, of which the general ground is impervious to moisture, while the written lines, being denuded of varnish, are quite porous, and afford an easy passage to an aqueous liquid. In the early days of papyrograph printing, a pad, saturated with persulphate of iron, was placed at the back of the stencil, while the paper to be printed on was moistened with a solution of ferrocyanide of potassium. The iron salt being forced through the porous lines by a gentle pressure, reacted on the ferrocyanide; a blue impression was the result. It is now, however, found to be more convenient to print from the stencil by means of an aniline colour dissolved in glycerine, and the colouring power of this kind of ink is so great that dry paper may be used for receiving the impression. On a velvet pad which has been moistened with a solution of aniline blue in glycerine, is laid the paper stencil, this having been previously brushed over at the back with a little of the ink. It is now merely necessary to place sheets of paper on the upper face of the stencil, and to apply gentle pressure by means of an ordinary copying-press, in order to obtain copies rapidly and easily. About 600 copies can generally be taken from one stencil.

(24) Pumphrey's "collograph" depends on the fact that when a film of moist bichromated gelatine is brought into contact with ferrous salts, tannin, or certain other substances, the gelatine is so far altered as to acquire the property of attracting a fatty ink. Pumphrey supplies plates of slate or glass covered on one side with a thin film of gelatine, and these are prepared for use by being soaked in a weak solu-

tion of potassium bichromate, all excess of moisture being then removed by first wiping with a cloth, and afterwards rolling paper on the damp surface. A drawing or writing, which has been made with either an ordinary iron and gall-nut ink, or with a special ink, is transferred to the prepared plate, just as in the case of the transfer to zinc. The original being removed, the plate is inked by means of a roller, moistened by a sponge, in order to remove any trace of ink from the ground, and then printed from, much as if it were a lithographic stone, or a zincographic plate.

(25) Some methods depend on the writing of an original with a very intense ink, and then dividing the ink, so as to obtain a number of feebler copies. The ordinary method of obtaining one or two reverse copies of a letter on thin paper is of this nature; but these processes, which are capable of yielding 30 to 60 fairly good copies, depend on the use of a solution of an aniline colour for writing. In the case of copying processes introduced by Pumphrey and Byford, the writing is executed with a strong solution of an aniline colour on thin, and tolerably hard, paper. The writing quite penetrates the thin paper, and on pressing a sheet of moistened paper against the back of the original, some of the aniline colour will set off on the damp paper, giving a direct copy of the original writing. In the same way, numerous copies may be produced; but processes of this kind cannot reproduce very fine lines with distinctness. A somewhat analogous arrangement for obtaining numerous copies is afforded by Waterlow's "multiplex copying portfolio" and its contents. The writing is done with the aniline ink, and a damp sheet of very soft and porous paper is pressed down on the writing. This soft paper absorbs a large proportion of the aniline ink, and itself forms a reversed printing-surface, capable of yielding a considerable number of direct copies to damp sheets of paper.

(26) *Hectograph or Chromograph.*—This process obviates the necessity for using damp paper to receive the impression. The writing is executed on ordinary writing-paper with aniline ink, and when the lines have dried, the original is transferred to the surface of a slab of soft gelatinous composition, analogous to that used for making printers' rollers, contact being established by gentle rubbing with the hand. The original, after being allowed to remain in contact with the gelatine slab for about 2 minutes, is stripped off, leaving the greater part of the ink on the gelatine. To obtain copies, it is merely necessary to lay paper on the slab, and rub down with the hand or a soft pad. When the requisite number of copies is obtained, or the lines are effaced, the slab can be cleaned with a damp sponge, and is again ready for use. The composition for the slab may be prepared thus: 1 lb. gelatine (or 1½ lb. glue) is soaked in water till it becomes flaccid, after which it is melted in a water-bath with 6 lb. common glycerine, the heat being maintained for a few hours to drive off all excess of water. The mixture is poured into zinc trays ½ in. deep, and allowed to set. Another composition is 130 parts water, 75 baryta sulphate, 30 gelatine, 30 sugar, 180 glycerine. The ink is prepared by dissolving 1 part aniline blue-violet in a mixture of 7 parts water and 1 alcohol. Coloured inks will give 150 copies, and special black ink 50.

(27) The 'Papier Zeitung' gives the following directions for making hectograph sheets: Soak 4 parts of best clear glue in a mixture of 5 parts pure water and 3 parts ammonia (presumably liquor ammonia) until the glue is thoroughly softened. Warm it until the glue is dissolved, and add 3 parts of granulated sugar and 8 parts of glycerine, stirring well and letting it come to the boiling point. While hot, paint it upon clean white blotting paper, with a broad brush, until the blotting paper is thoroughly soaked, and a thin coating remains on the surface. Allow it to dry for 2–3 days,

and it is then ready for use. The writing or drawing to be copied is done with the usual aniline ink upon writing paper. Before transferring to the blotting paper, wet the latter with a sponge or brush and clean water, and allow it to stand one or two minutes. Place the written side down and stroke out any air bubbles, and submit the whole to gentle pressure for a few moments, remove the written paper, and a number of impressions can then be taken in the ordinary way. When the impressions begin to grow weak, wet the surface of the "graph" again. This "graph" does not require washing off, but simply laying away for 24–36 hours, when the surface will be ready for a new impression.

(28) Magne has introduced an ink or pencil possessed of such qualities that a writing or drawing made with it, when dry, can be covered with a fatty ink, and the paper being saturated with a suitable liquid, it can be completely copied without being injured itself. Common printing ink acts towards this saturating fluid in the same way as Magne's pencil, so that printed matter and cuts can be reproduced. The liquid employed to saturate the paper consists of 15 oz. acid (sulphuric is the best) and 35 oz. alcohol. If intended for autographic reproduction, 100 oz. water should be added. The proportions may be varied, but to prevent injury to the original, there must be plenty of alcohol. Autographs for reproduction must be written with ink or pencil, of such composition that they can take up the fatty ink; the same kind is used for all kinds of paper, whether sized or not. The portions of the paper not covered with ink are protected against the lithographic ink by an acid composition which repels the greasy ink, does not attack the cellulose, and, therefore, leaves the original perfectly unchanged. The ink consists of proteine substances (albumen, caseine, fibrine, etc.), and of bichromated salts, alum, cyanides, etc. In making it there is dissolved a quantity of water 2 or 3 times as great as that of the albumen or other proteine substance, a mixture of 2 parts of a bichromate or alum, and 1 of prussiate of potash. A certain quantity of albumen is also beaten up with an equal weight of water. The proportion of salts to that of albumen is about as 6 to 100. The two liquids are mixed intimately, and a suitable quantity of pigment is added. The ink, which must have pretty deep colour, is unchangeable, remains thin and fluid, and can be used with a pen, pencil, or drawing pen, on any kind of paper, except very heavy paste-board or too thin silk paper. Pencils or crayons used in this process consist chiefly of paraffin coloured with very fine lamp-black or ivory-black, or with any other very finely powdered pigment for other colours. When lamp-black is used, the proportions are, 16 oz. lamp-black to 100 oz. paraffin. To make pencils of different hardness, the paraffin is melted and the colour added, and then a certain quantity of ordinary rosin (colophony) is added, usually not over 10 per cent. The mass is cast into candle moulds when in a semi-liquid state, and taken out when cold. These cylinders are then cut in pieces and wrapped in strong paper, or covered with wood like common lead pencils. The method of taking a copy of what has been written or drawn is as follows: If the work was done in ink, it is ready to copy as soon as dry. If in pencil, the drawing must be steamed a few seconds by holding it over a vessel of boiling water. After being air-dried, it is carefully floated, face upward, on the acidified alcoholic liquid. There it is left until thoroughly saturated, and then it is spread out on a sheet of glass or smooth board, and inked with an ordinary lithographic roller. All the letters and lines will be covered with the greasy ink. As soon as sufficiently inked, it is carefully pressed with a damp sponge on those places that have taken the ink, and then washed with water. To remove the excess of mois-

ture, it is spread out on a plate of plaster-of-Paris, and then transferred to a stone or zinc plate, and the copy taken. The precautions necessary in order to preserve the original copy are to wash it with carbonate of ammonia, or of soda, rinsing with cold water, removing the excess of water on a plate of gypsum or blotting-paper, and then drying it in the press between sheets of porous paper. To reproduce anything printed with printers' ink, the following method is pursued: The mixture of alcohol and acid is applied either to the face or back of the print with a brush. The liquid instantly penetrates the paper; the surface is then quickly washed off and the sheet carefully spread out on a damped plate of glass or wood. There it is inked with an ordinary lithographic ink roller, gently washed to remove the excess of acid, dried on the gypsum plate, put on the stone, and a sufficient pressure applied. The transfer of the negative is finished, and the ordinary lithographic process begins. If both sides of a drawing or manuscript are to be copied, both sides are blackened, one after the other, the operation being carried out on one side as far as the transfer to a stone, and then the other side is inked and transferred. When copies of printed matter are to be made the negative is transferred to a polished zinc plate, and then etched in the usual manner with acids.

(29) *Willis's process* is founded on the action of bichromates on organic matter, the printed image being coloured by means of an aniline salt; it is extremely useful for copying plans and simple line-subjects. The operation is as follows: Sized paper is floated in potassium bichromate containing a little phosphoric acid; it is next exposed beneath a translucent positive, and when the image of the latter is clearly shown, it is subjected to the action of aniline vapour. The result is that the parts shielded from the light by the lines of the positive are deeply coloured (green, black, or reddish, according to the aniline salt used), while the other parts retain the weak tint of the reduced chromium oxide. In developing the print, it is exposed to the contact of the vapour from aniline dissolved in spirit of wine the solution being placed in a basin, and heated by a spirit-lamp. The prints are fairly permanent after washing.

(30) *Poitevin's Powder.*—A mixture of gum arabic, sugar, and glycerine, with some sensitising solution of potassium bichromate, is poured upon an impervious surface (e.g. a glass plate), and dried by warmth. Thus prepared, the plate is immediately exposed beneath a translucent positive for a few minutes. The parts affected by the light become hygroscopic, in proportion, to the duration of the exposure, and intensity of the light, and any impalpable powder delicately brushed over the plate will adhere to the hygroscopic parts, according to their degree of moisture, thus forming a reversed copy. The developed image is coated with collodion, and transferred to paper unreversed, the soluble bichromate being washed out in the operation. Obernetter's recipe for the sensitising solution is: 4 parts dextrine, 5 white sugar, 2 ammonium bichromate, 2 to 8 drops glycerine for every 100 c.c. of water, and 96 parts water. The glass plate is sometimes previously coated with collodion.

(31) *Polygraphic Paper.*—Instead of using a tray filled with a compound to receive the ink, Alissoff employs sheets of "polygraphic" paper, prepared in the following manner: Sized or unsized paper is coated, on one side, with a composition consisting of glue, or gelatine, glycerine, soap, and water, approximately in the following proportions, which have been found to give good results in practice: 80 lb. animal glue or gelatine, 20 lb. glycerine, 30 lb. soap, 200 lb. water. The paper is occasionally found too sticky for use, depending on the surrounding temperature and the quality of the materials.

To obviate this objection, wash the prepared paper with a solution of alum, the strength of which can only be determined by experiments in each case. The paper may be of different thicknesses, and rendered transparent. The ink found to give the best results for written documents is prepared by dissolving 1 lb. aniline in 1¼ lb. alcohol, and adding, when dissolved, as much water as is necessary to render it sufficiently fluid. It may then be bottled for use. In producing the "matrix," take a sheet of prepared paper, and lay it on a sheet of damp flannel, placed upon a zinc plate or an oil paper. Sponge with clean water, or, in hot weather, with water containing a little alum, and place the dry original upon the prepared paper. Over that place another piece of damp flannel, zinc, or oil-paper, and put the whole pile into an ordinary copying-press. A good matrix can be obtained by mere pressure of the hands without a press, although a press is preferable. The text must be written, drawn, or printed with aniline ink, taking care that the pen be quite clean and always full of ink. The ink when dry ought to shine like a metallic surface. In taking copies from the "matrix," after having detached the original, place a sheet of ordinary paper in the place of the original, and proceed in the same way as when producing the matrix; but if copies or "matrices" are to be taken from 2, 4, 6, or 8 pages at once, place a sheet of damped polygraphic paper on each page, with damp flannels and zinc sheets between the leaves, and proceed in the way described.

(32) Komaromy, of Budapest, paints a paper with the following solution: 1 oz. gelatine, 5 oz. glycerine, ½ oz. Chinese gelatine, 1 oz. water. The manuscript is written with the following solution: 100 parts water, 10 of chrome-alum, 5 of sulphuric acid, 10 of gum arabic. The manuscript is laid on the first paper, and the surface of the latter is thereby rendered incapable of taking up an aniline solution with which the first surface is then flowed. Excess of colour is absorbed with silk paper, and negative impressions are then taken on clean paper.

Mechanical Methods.—(1) *Stencils.* A class of printing stencil is made by the mechanical perforation of suitable paper or tissue. Stencils perforated by a rapidly rising and falling needle-point, actuated by a treadle, have long been used for the printing of embroidery patterns. In such a case, powdered colour, mixed with resin, is dusted through the stencil, after which the device is fixed by the application of sufficient heat to soften the resin. Edison proposes to use such perforated stencils for ordinary autographic printing purposes, and replaces the complex treadle perforating machine by a kind of pen, in which a needle-point is made to move rapidly up and down by means of a small electric motor attached to the instrument. When Edison's electric pen is connected with a battery of two elements, the needle rapidly passes in and out of the perforated point of the instrument. If written with on a piece of blank paper, the paper becomes perforated. The sheet of ink-proof paper having been written on with the electric pen, can be used as a printing stencil by merely laying it down on a sheet of white paper and passing an inking-roller over its back The operation of printing is very rapid, so that many copies can be produced in a short time. Other perforating pens have followed in the wake of Edison's electric instrument, among which may be mentioned the "horograph," a very convenient and portable clockwork pen. A pneumatic pen, in which the motive power is a stream of air supplied from a foot-bellows, has also been introduced into the market. A still more complex and expensive arangement than either of the preceding, for producing perforated stencils, consists of an induction coil capable of giving a sufficiently powerful spark to perforate the stencil-paper; and this spark is made to continually pass between a partially insulated metallic pen and a metallic plate on which the stencil paper is laid.

(2) All these perforating arrangements have the disadvantages of being expensive, complex in construction, and liable to get out of order when used by unskilled persons, while the perpendicular position in which the mechanical perforating pens must be held, necessarily hampers the freedom of the writer. In a new perforating method introduced by Zuccato, the impervious stencil-paper is laid on a hardened steel plate, cut on the face like a fine file, and the writing is executed by means of a point or style of hardened steel. Under these circumstances, the teeth of the file-like plate perforate the paper wherever the point of the style exerts pressure, and a stencil eminently adapted for printing from is the result. This kind of printing is called "trypograph." A sheet of the prepared paper is laid on the file-like plate and written upon with the hardened steel pencil, the operation of writing being as easy as if a pencil were employed. By fixing the stencil on the frame of a desk-like press, placing a sheet of white paper underneath, and then pushing over the upper surface of the stencil an indiarubber scraper or squeegee charged with printing-ink, the ink passing through the perforation produces a copy of the original writing. As many as 6000 copies can be obtained from one stencil. Thin metallic plates are readily perforated by Zuccato's method, and calico receives the trypographic impression admirably.

(3) *Tracing Cloth.*—Varnish the cloth with Canada balsam dissolved in turpentine, to which may be added a few drops of castor-oil, but do not add too much, or it will not dry. Try a little piece first with a small quantity of varnish. The kind of cloth to use is fine linen; don't let the varnish be too thick.

(4) *Drawing on Tracing Cloth.*—A correspondent of the 'Moniteur Industriel' refers to the difficulties encountered in tracing upon cloth or calico, especially the difficulty of making it take the ink. In the first place, the tracing should be made in a warm room, or the cloth will expand and become flabby. The excess of glaze may be removed by rubbing the surface with a chamois leather, on which a little powdered chalk has been strewn; but this practice possesses the disadvantage of thickening the ink, besides, it might be added, of making scratches which detract from the effect of the tracing. The use of ox-gall, which makes the ink "take," has also the disadvantage of frequently making it "run," while it also changes the tint of the colours. The following is the process recommended: Ox-gall is filtered through a filter paper arranged over a funnel, boiled, and strained through fine linen, which arrests the scum and other impurities. It is then placed again on the fire, and powdered chalk is added. When the effervescence ceases, the mixture is again filtered, affording a bright colourless liquid, if the operation has been carefully performed. A drop or two must be mixed with the Indian ink; and it also has the property of effacing lead pencil marks. When the cloth tracings have to be heliographed, raw sienna is also added to the ink, as this colour unites with it most intimately, besides intercepting the greatest amount of light.

(5) Letterpress or illustrations printed in printers' ink may be copied by simply wetting a piece of stiff paper or card, laying it on the matter to be copied, and rubbing it over with an agate burnisher or old toothbrush handle. If the ink has got dry through age or being kept in a hot room, moisten with spirits of wine or toilet vinegar. Have a soft blotting-pad beneath.

(6) *Permanently Moist Copying Paper.*—A perpetually damp copying paper, always ready for use, is described in the 'Paper Trade Journal.' It is prepared by dissolving 1 lb. of

chloride of magnesium in a moderate quantity of warm or cold water—about 1 lb. When dissolved, apply this solution with a brush to ordinary copying paper, whether in book form or otherwise, or preferably by means of cloth pads saturated with the liquid, then place these pads between any suitable number of leaves; apply pressure, at first very moderate, until the absorption by the paper is complete; then remove the cloth pads, and apply with the press a strong pressure; it is then ready for use.

Paper prepared by this process will remain permanently moist under ordinary temperature, and if made dry by an extraordinary heat, will regain its moisture upon being subjected to the common atmosphere.

One advantage of this method is, that the sheets of paper will not adhere to each other, as is frequently the case, when the paper is prepared with compounds containing glycerine, etc. The above process is patented.

(7) *Transparent Paper.*—The following is a method of making any kind of drawing paper transparent for tracing and copying in ink or colours. The paper is stretched in the usual way over the drawing to be copied or traced. Then, by the aid of a cotton pad, the paper is soaked with benzine. The pad causes the benzine to enter the pores of the paper, rendering the latter more transparent than the finest tracing paper. The most delicate lines and tints show through the paper so treated and may be copied with the greatest ease, for pencil, Indian ink, or water-colours take equally well on the benzinised surface. The paper is neither creased nor torn, remaining whole and supple. Indeed, pencil marks and water-colour tinting last better upon paper treated in this way than on any other kind of tracing paper, the former being rather difficult to remove by rubber. When large drawings are to be dealt with, the benzine treatment is only applied in parts at a time, thus keeping pace with the rapidity of the advancement of the work. When the copy is completed, the benzine rapidly evaporates, and the paper resumes its original white and opaque appearance without betraying the faintest trace of the benzine. If it is desired to fix lead-pencil marks on ordinary drawing or tracing paper, this may be done by wetting it with milk and drying in the air.

Pencils. — (1) Pencils made to produce marks from which copies can be obtained in an ordinary copying-press, have usually the disadvantage that, consisting mainly of aniline, the colour of the copy fades very soon. Gustav Schwanhauser overcomes this difficulty by doing away with aniline altogether. He prepares the pencils as follows: 10 lb. of the best logwood are boiled repeatedly with 100 lb. of water, and the decoction so obtained is evaporated down to 100 lb. The liquid is heated to the boiling point, and small quantities of the nitrate of chromium added, till the bronze-coloured precipitate formed at first is redissolved in a deep dark-blue colour. The liquid is now evaporated to the consistency of a syrup, and the finest levigated fat clay is added in the proportion of 1 part of clay for every 3 or 3½ parts of the extract. To form a good mass to manipulate, a little mucilage of gum tragacanth may be used. The quantity of nitrate of chromium must be in the right proportion to the extract, as a surplus prevents an easy writing, and a deficiency prevents the easy solubility of the mass for copying purposes. No other salt of chromium will answer the purpose, as they all crystallise, and the crystals formed in the mass will cause the pencil to be rough and brittle. Nitrate of chromium does not crystallise; its combination with the extract of logwood is the most easily soluble and the blackest ink. The nitrate is prepared as follows: 20 lb. of chrome-alum are dissolved in 200 lb. of boiling water. To the solution is gradually added a solution of carbonate of sodium of the same strength, till all the hydrated oxide of chromium has been precipitated. After subsidence of the precipitate, the supernatant liquid is decanted, and the precipitate is washed with distilled water, till the filtrate does not contain any more traces of sulphate of potassium and sodium as may be shown by the addition of a little solution of chloride of barium. To the precipitate collected [illegible] the filter are successively added small portions of heated pure nitric acid, previously diluted by its own volume of distilled water, in such quantity that on boiling, a small quantity of the hydrated oxide remains undissolved. In this way a perfectly saturated solution of nitrated oxide of chromium is obtained, containing no excess of nitric acid. This is a great advantage, since an addition of nitric acid to the ink changes its colour to a muddy red. Another advantage is that no basic nitrate is formed, and no excess of hydrated oxide is contained in the produced salt, as is the case in most other salts of chromium. Such basic salts form an insoluble compound with the extract of logwood, instead of entering into solution. The writing furnished by these pencils is easily transferable; it is of a penetrating jet-black colour. Alkalies and acids have no effect on the ink. ('Schweizerisches Gewerbeblatt.')

(2) *Faber's pencil* for copying writing or designs is made of different degrees of hardness, and is stated by the inventor to combine all the advantages of the very best lead pencils. Four kinds are manufactured. No. 1, very soft; composed of 50 parts of aniline, 37·5 graphite, and 12·5 kaolin. No. 2, soft; 46 parts aniline, 34 graphite, 24 kaolin. No. 3, hard; 30 parts aniline, 30 graphite, 40 kaolin. No. 4, very hard; 25 parts aniline, 25 graphite, 50 kaolin. These materials are pounded and mixed with the greatest care, and afterwards made into a paste with cold water. After the paste has been well worked and rendered perfectly homogeneous, it is passed through a wire screen, which divides it into strips of suitable dimensions. These are dried in an ordinary room, and afterwards fitted and glued into wooden cases like common lead pencils. The new pencils may be used like ordinary copying pencils for the reproduction of writing or designs. A sheet of thin paper wetted is laid over the sheet to be copied, and the details are gone over with the copying pencil. The action of the moisture on the aniline in the pencil gives a deep tint to the tracing, resembling that of ordinary writing-ink.

Carbon Paper.—(1) Lampblack, 10 parts; olive-oil, 10 parts; cerasin wax, 2 parts; petroleum ether, 20 parts (or the wax may be increased 10 parts, with an additional 30 parts of the ether). Rub the black and oil together in a mortar, adding the oil little by little, then put in a pan, and after heating it a little, add the [illegible] When this is melted and mixed, remove the pan from all fires and lights, and add the ether. Apply the mixture to hot paper, and then return, the paper to the oven for about 20 minutes, so that the mixture may thoroughly soak in. Take from the oven, and wipe off any moisture with a clean rag, then hang up to cool. Prussian blue may be added to the black to intensify it, or to give a blue shade. (2) 12 parts lard, 2 parts beeswax; melt together, and add sufficient lampblack and a little prussian blue. (3) 10 parts castor-oil, 10 parts lampblack, 2 parts cerasin wax, 20 parts petroleum ether. Proceed as (1). (4) Paraffin wax and heavy petroleum (lubricating) oil or castor-oil, melted together and lampblack added. The proportions of the two may be varied according to the purpose the carbon paper is to be put to. Wax in excess makes it difficult to make an impression, while oil in excess will allow of an impression being made by merely pressing the finger on the paper. Any intermediate degree can, of course, be had. The lampblack (or drop-black or gas-black) should be ground with the oil and wax in a mill. Blues and blue-blacks can be produced by adding prussian blue or an aniline colour that is soluble in oil. The paper should be heated, the mixture should be fairly hot, and a little heat is desirable afterwards to cause the paper to become well saturated.

(5) *Dieterich's Paper.*—The manufacture may be divided into 2 parts, viz. the production of the colour and its application to the paper. For blue paper, he uses Paris blue, as covering better than any other mineral colours. 10 lb. of this colour are coarsely powdered, and mixed with 20 lb. ordinary olive-oil; ½ lb. glycerine is then added. This mixture is, for a week, exposed in a drying-room to a temperature of 104° to 122° F. (40° to 50° C.), and then ground as fine as possible in a paint mill. The glycerine softens the hard paint, and tends to make it more easily diffusible. Melt ½ lb. yellow wax with 18¾ lb. ligroine, and add to this 7½ lb. of the blue mixture, mixing slowly at a temperature of 86° to 104° F. (30° or 40° C.). The mass is now of the consistence of honey. It is applied to the paper with a coarse brush, and afterward evenly divided and polished with a badgers' hair brush. The sheets are then dried on a table heated by steam. This is done in a few minutes, and the paper is then ready for the market. The quantities mentioned will be sufficient for about 1000 sheets of 36 in. by 20, being a day's work for 2 girls. For black paper, aniline black is used in the same proportion. The operation must be carried on in well-ventilated rooms protected from fire, on account of the combustibility of the material and the narcotic effects of the ligroine. The paper is used between two sheets of paper, the upper one receiving the original, the lower one the copy.

Transferring.—(1) *Pixis Process for Transferring Photographs to Wood.* A phototype plate, representing the picture that is to be transferred, or its negative, is produced: it must be of the same size as the copy is to appear. The printing ink used in the phototype process, to which any tone of colour may be given, is carefully mixed with a siccative, Japanese gold size being preferred. The quantity to be taken of this liquid depends on the question whether the picture is to dry rapidly or slowly. As a rule 15 to 18 drops of Japanese gold size to each ½ cub. in. of printing ink may be considered adequate for producing that indelibility which must be attained in most cases. The photographic picture, after having been rolled over with this preparation, is transferred upon the material either directly or by means of transfer paper. The transfer upon ebony or upon any other dark material takes place by means of a white colour prepared in the above manner or of any desired light colour. But the negative required for producing the phototype plate must in this case be converted into a positive, which may be done by the gelatine process. A thin white paper, one side of which has been prepared with an entirely smooth layer of paste and well pulverised chalk, or in some instances only with a thin layer of paste, must, in dry condition, be so placed upon the phototype plate carefully impregnated with the above ink composition, that its prepared pasted side lies underneath; the paper is then softly pressed with a damp sponge, whereupon the whole is drawn through a press, if possible but a single time. The paper to which the picture has thus completely been transferred is then carefully taken off the plate, and can be immediately transferred on other materials, or it may be kept for the purpose, [illegible] being transferred at a future time. In order to keep it damp for the latter purpose, it must be placed between damp blotting paper and hermetically packed up. The object to be printed must be fastened in the press, and the transfer paper, after having been moistened from the reverse, is laid on that part on which the picture is to appear. Some sheets of damp blotting paper are then placed upon the transfer paper, and the whole, together with the usual cover, is drawn through the press once or several times, according to the object upon which the transfer is being made; this done, the transfer paper is moistened with a sponge dipped in cold water until it can easily be detached from the transferred picture without leaving on it any traces of the printing ink. In order to render the picture completely clear, the layer of chalk attaching to it directly after the act of printing must be removed by means of a soft sponge which has been wetted in cold water. Boxwood blocks are prepared for the process in the following manner: A quantity of flake white ground in oil, such as is used by painters, must be mixed with a few drops of Japanese gold size, and as much benzine added as will make it possible to work the whole in the thinnest quantity attainable and very swiftly by using a broad brush. When the wood-engraver has finished his task, he removes the white with turpentine or spirit. Upon smaller objects, such as medallions in ivory, metal, wood, etc., the transfer, if executed without delay, can be performed directly from the paper by using a smoothing-bone. This fact is important with regard to all such objects as are not quite flat but somewhat vaulted. In order to transfer a picture on porcelain, clay, or glass, Pixis takes exclusively enamel colours, and gets them upon the phototype plate by rolling. If the tone of the picture is to be lowered or strengthened, or if a variety in colouring is desired, either the phototype plate, *the transfer* or *the material*, is powdered over with dry colours of the required tint before the enamelling takes place, and while the pictures are still damp. This powdering with dry colours may also be applied to pictures which are to be transferred to leather, textile fabrics, metals, wood, minerals, etc. The above-named materials, as likewise painted canvas, wood, metal, etc., may also, after the picture has been passed over, and before the transfer takes place, be prepared in the desired colour by means of oil, distemper, wax, porcelain, and water colours. Every picture, if transferred in the described manner upon wood in several colours or one colour, may, when sufficiently dried, be polished, oiled, and otherwise treated without becoming damaged. Pictures transferred on textile fabrics can be made to stand washing by drawing them, when dry, through a solution of glaire, squeezing and heating them to a temperature of 230° to 270° F. (110° to 120° C.).

(2) Take a piece of wood, such as lime, pine, or fir, and get a good, smooth surface on it by planing, glass-papering, etc., being very careful not to leave any woolliness or scratches on its surface after using the sandpaper. The next thing to do is to polish the surface well with ordinary white French polish; but do not finish off with spirits, and be sure and have a good coat of polish on. Now take the picture and lay it on the wood, with picture side to the polish; then take a piece of sponge or cotton wool, and dip it into methylated spirits; brush the back of the paper over with this, being sure it is well saturated, and that there are no air-bubbles left under it. Now put it aside for a time, until all the spirit has evaporated and the paper is quite dry, when it will be found to be securely fastened to the wood. Now, to get rid of the paper, it must be gradually rubbed away with water, using the tips of the fingers or a piece of soft indiarubber, until the picture appears equally distinct over the whole surface, when the rubbing down is to be discontinued. Now put it aside again for 4 or 5 hours until all the water has evaporated, and then polish with the white French polish in the usual way, as if you were polishing a piece of wood. The white French polish is made from white shellac and methylated spirit.

(3) *Transferring Engravings to Paper.*—The liquid used for this purpose may be made by dissolving 1½ dr. common yellow soap in 1 pint hot

water, adding, when nearly cool, ¾ fl. oz. spirit of turpentine, and shaking thoroughly together. Apply the fluid liberally to the surface of the engraving, or other printed matter, with a soft brush or sponge (being careful not to smear the ink, which soon becomes softened), and allow it to soak for a few minutes; then well damp the plain paper on which the transfer is to be made, place it upon the engraving and subject the whole to moderate pressure for about one minute. On separating them, a reversed transfer will be found on the paper. This transfer will not be equal in intensity to the original, as only a part of the printer's ink is removed. If the print be very old, a longer soaking and more pressure may be necessary.

(4) *Transfer Process on Glass.*—Dr. Henoque's method of transferring outlines obtained by means of a stylus on blackened paper on glass is frequently employed, only the outlines are generally executed on paper rolled on cylinders. To photograph these designs, or project them on a screen, it is usual to transfer them to glass without any alteration, the transparency of which renders it capable of being used in either way. Dr. Henoque, after removing the blackened sheet from the cylinder round which it has been rolled, spreads it on a glass, and coats the smoked surface with collodion. As soon as the collodion is set, the plate is plunged into water, and, after a moment, a floating pellicle of collodion rises to the surface, bearing the film or smoke and the traced outline. It is next transferred to glass by means of a sheet of paper, and made to adhere with gum applied all over the plate. Great precaution must be taken to fix the edges of the pellicle by strips of paper gummed. When dry, it forms a perfect negative, or may be used as a transparency to project on a screen. In the same way, as Poitevin has indicated, chalk drawings may be removed from paper and transferred to glass. The paper for smoking should be albuminised and lightly gummed. To smoke glasses on which lines are to be traced with a point, they may be coated with lamp-black paint, and the blackened surface afterwards passed over a petroleum lamp flame. The smoke covers over all the inequalities of the coat of paint, and the design may be immediately traced. It can also be taken off and transferred to another glass in the way already indicated. ('Photo. News.')

Mounting Drawings and Tracings.—One of the most common details in the routine of the drawing office is the mounting and repairing of tracings and drawings which have either been made on paper too flimsy to stand the wear and tear which they will have to undergo, or which are falling to pieces from the rough treatment which they have received in the shops or elsewhere. Like many other minor details, it often fails to receive the attention which, if paid to it, would be amply repaid. It is usually the first task assigned to a new pupil, who, from ignorance of the materials used, and of the best method of setting about his work, too often "makes a mess of it." To avoid this, and to save the time which it occupies, it is a very common practice to use "tracing-cloth" for all tracings which are likely to be frequently handled and folded. Every one knows the disagreeable nature of this material. From its "greasiness," as compared with ordinary tracing-paper, a "greasiness" which cannot be overcome by ox-gall, it is difficult to make the ink "lie," and, from its non-absorbent qualities, the lines take much longer to dry and are more liable to be smeared. As the ink lies on the surface, the lines are liable to wash, and any colouring that may be necessary has to be applied on the back or wrong side, and any erasure that may be necessary, or any accidental drop of water, leaves a disagreeable white mark. It is no exaggeration to say that three tracings may be made on ordinary tracing-paper in the time required to make two on tracing-cloth.

The method which we are about to describe is not only satisfactory, but very easy, and requires only ordinary care, and no special skill.

Let us suppose that we wish to mount a tracing. We take a drawing board, which must be perfectly clean and made without glue in the joints, and lay it on a table, or on trestles, if possible, so that we can get at it from all sides. We then take a stout piece of calico, about an inch larger all round than the tracing to be mounted, and pin it down with a tack at each corner on another table, which we have previously covered with old newspapers. We then lay the tracing face downwards on the drawing-board, and with a soft sponge wet it thoroughly all over. Then, raising first one half of the tracing and then the other, we flood the board well with clean water. The tracing now lies floating on a thin film of water. Then, taking a moist sponge and commencing at the centre, and working outwards towards the sides in turn, we press the tracing down on to the board, driving the water out at the edges. In the same manner we work out all the water from each corner in turn, always working from the centre to the edges, and taking care to leave no "blobs" of air or water behind us, and wiping off all superfluous moisture from the top or back of the tracing. By viewing it slantwise across the light, it is easy to see if this has been properly done. If it is an old or badly-torn tracing, we can easily fit any detached pieces and, as it were, glue them down in their place on the board with the water. If it is necessary to unite two sheets, we first lay down the larger, if of different size, as above described, and then the other, commencing from the point of junction and working outwards. Then, with a stout brush we spread the paste—which we suppose already prepared—well, and evenly over the calico, beating it thoroughly into the interstices of the cloth and taking care to leave no lumps or superfluous quantity, and, if necessary, picking off any bristles out of the brush, etc. Allow this to dry and give another thorough coating of paste, then, taking it by the corners (this is the only part of the operation in which any assistance is required), and turning it over and holding it at full stretch, we lay it on the tracing, taking care that, as far as possible, every part shall come in contact at the same moment. Once down it must not again be lifted, or it will probably pick up any loose pieces and remove them from their proper positions. Then, with the wet sponge, we proceed to press down the cloth in the same manner as we have previously spread the tracing, driving all air-bubbles out at the edges and wiping off all superfluous moisture. Then, turning back each corner in succession, as at B_1, till we can just see the corners of the tracing, we stick in four tacks or drawing-pins, not to hold it down, but merely to mark the corners. A A (Fig. 126) is the board; B B, the cloth; B_1, one of the corners turned back; C C, the tracing underneath; C_1 C_1, tacks at the corners. Then, pressing the corners down again. we set aside to dry. If wanted in a hurry, it may be dried, not too quickly, before the fire, allowing at least two hours for this process; but it is better to allow it to dry slowly and leave it until the next day. When dry, cut with a sharp knife from tack to tack, and the tracing will fall off. If the paste is good, it will be easier to split the paper than to tear it off the cloth. The remaining strips of cloth may then be torn off the board, and the board washed free from all traces of paste for future use.

It might be supposed that the colouring would run, and the lines be found all blotted and blurred after such rough usage, but such is not the case. Indian yellow, if laid on too thickly, will occasionally run, but not to a serious extent, and heavy lines of prussian blue would probably be found printed and reproduced on the board, but not blurred or smeared. But the best plan, if a very neat appearance is a *sine quâ non*, is to colour the tracing after mounting. The tracing will be found to have a surface for colouring far superior to the best drawing-paper, and as all superfluous ink has been removed by the process, lines and figures may be washed over in the most careless manner without any fear that they will run. Those who know the care required to wash over a heavy dotted line, will fully appreciate the advantage.

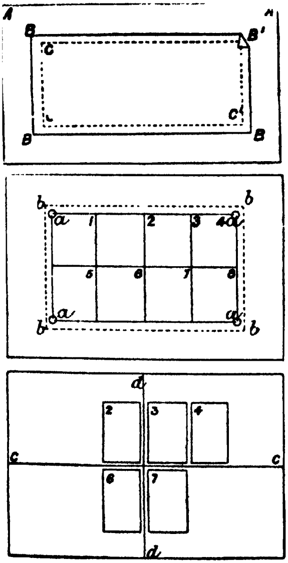

Fig. 126.

The absence of all distortion is a most remarkable feature in tracings mounted as above described, and may be readily tested by applying a straight-edge to any line. Any expansion or contraction is equal in all directions, and may be almost entirely obviated by a careful adaptation of materials. Very thin tracings should not be mounted on very thick cloth, or vice versâ. It will also be found that some tracing-papers will expand very much more than others, and, as is well known, will, if left free, contract upon drying to less than their former dimensions. But this tendency is counteracted, not only by the fact that the tracing remains stretched on the board until dry and cut off, but by the fact that the cloth will not contract upon drying, especially if the paste is well beaten into the interstices.

* * *

CRAYONS OR PASTELS.

CRAYONS, even black and dark colours, have a white paste as a basis, this having coloured matter added to it of the kind and quantity required.

Bases.—(*a*) Washed pipe-clay and washed chalk (whiting) equal parts; mix them into a paste with sweet ale made hot, and with a chip or two of isinglass dissolved in it.

(*b*) Take the finest powder of calcined oyster-shells, sifted through muslin; mix it up with water in which a little rice and a little white sugar-candy have been boiled; according to the quantity of rice, so will be the hardness of the crayon. The quantity of sugar-candy should not be more than the size of a filbert-nut to a pint of water.

(*c*) Take common pipe-clay in powder, mix it up into a paste with very strong soapsuds, made thus: Cut up 1 oz. of white soap into small shavings; dissolve it over the fire in ½ pint of water; stir into the mixture while hot the powdered pipe-clay as long as you can stir it. Spirits of wine added before the powders, to render the soap-water transparent, is an improvement.

(*d*) Dissolve 3 oz. of spermaceti in 1 pint of water, stir into it a quantity of fine-sifted or washed white colour till of a proper consistence. If to be mixed with dark powders, a very little ox-gall is an improvement.

(*e*) Melt 3 oz. of shellac in 2 oz. of spirits of wine; this will form a thick liquid; to this add 6 parts of pipe-clay and 1 part of oil of turpentine; grind all well together. The lighter the colour of the shellac the better; also if colours are to be added they should be ground up with the turpentine, before this is added to the rest.

(*f*) 1 part china clay, 1 part prepared chalk. Shred 1 oz. of curd soap into a pint of boiling water, add sufficient methylated spirits to make the solution transparent, then use it to make a paste with the clay and chalk and whatever colouring matter is to be used.

(*g*) Having prepared the pipe-clay and chalk, dry, moisten with methylated spirit in which a little white shellac has been melted. Add colouring matter.

The great object of attention is to procure the white chalk or pipe-clay without grit. To accomplish this, put the whiting into a large vessel of water and mix well, pour off the top into another vessel, and throw the gritty sediment away; repeat several times. When this is done, let the whiting settle, and then pour the water from it and dry it for use.

The compositions for white crayons and the requisite colours being prepared, and that chosen made up into a stiff paste, it is to be placed upon a smooth slab of marble slightly oiled. The paste is rolled out with a rolling pin, then cut into slips, and these are rolled into cylinders by the aid of a little flat piece of wood, then cut to the length of 3 in. each, and placed in a slow oven or drying stove to become hard.

Instead of rolling the composition, it may be forced through the nozzle of a tin funnel, this is better for the delicate colours than rolling them; when dry they may be pointed.

Colouring Matter.—(1) The colour alters very much in drying, so that in mixing an allowance must be made for this effect.

Black.—(*a*) Charcoal is first to be sawn into 3-in. lengths, free from knots; then saw them longitudinally in narrow strips. Procure a tin trough about 4 in. by 3, and partly fill it with white wax; this being properly melted, the pieces of charcoal are to be saturated for forty-eight hours, and after draining they are fit for use. (*b*) When white paste is employed, the only powdered colour to be used is lampblack, all the others are apt to get mouldy. (*c*) 10 parts pipe-clay, 8 parts lampblack, ½ part prussian blue. Grind with water to a stiff paste.

Blue.—(*a*) A good soluble colour is prussian blue, but it is hard to grind. Dissolve it in water, then put the solution in a hole cut in a piece of chalk, this will absorb the water, and leave a great portion of the colour ready for mixing. Blue verditer is a good bright colour, but is so gritty as to require washing, as recommended for whiting. The same may be said of smalts of cobalt. (*b*) Pipe-clay and ultramarine.

Browns.—These are Cologne earth; umber, raw and burnt; sienna, raw and burnt; and vandyke brown; treated as the blue.

Carmine and Lake. — Crayons of these colours are generally hard; when made with powdered colours, the proper way of mixing is to dissolve the colour first in water or spirits of wine, and add it to nearly-dry white colour, grinding the whole well together. There should be four or five shades. Madder is not used.

Greens.—These may be either simple colours, as emerald green, prussian green, green carbonate of copper; or better formed by adding the compositions of the yellow and blue crayons together. Raw and burnt sienna may also be used in combination with prussian blue or indigo. Good green crayons are more difficult to make than those of any other colour.

Mixed Colours. — Mixed or half colours are produced by an admixture of the colours required in the paste. Thus a combination of blue and carmine produces a purple; the yellows and red united form orange; black and carmine is a beautiful tint for shading; vermilion and black form a fine rich brown; green and brown form an olive colour; and red and brown a chocolate.

Vermilion and Red Lead, Red Ochre, Indian Red and Venetian Red.—Each of these may be well ground in water, and when wet, mixed well with the white in different shades. These will make various reds, as well as salmon colour, flesh colour, or orange. Hematite or crocus, of itself, ground and mixed with a little size, forms an excellent crayon.

White.—The best whites to employ are whiting or prepared chalk, pipeclay, alum white or alumina, oyster-shell white, calcined bones, etc.

Yellows. — Dissolve the colours, which are Naples yellow, King's yellow, and yellow lake, in spirits of wine, and mix as for carmine. The chrome yellows are not so useful, because less durable. Gamboge, Indian yellow, and gall stone are not employed, but the various yellow ochres make good crayons.

(2) Colours for crayons (to be added to the white paste). *White*: Zinc white, Paris white, satin white, blanche fixe. *Blues*: ultramarine, prussian blue, cobalt blue. *Browns*: vandyke brown, raw and burnt Turkey umbers, Cappah and Cassel browns, raw and burnt sienna. *Blacks*: lampblack, drop black, ivory black. *Greens*: emerald green, chrome greens, zinc greens. *Reds*: venetian red, Indian red, light red, red oxide, carmine, vermilion, madder red. *Yellows*: cadmium yellow, zinc chrome, yellow ochre, raw sienna. An innumerable variety of tints may be made by mixing the above.

(3) With some exceptions, the colours employed in crayon painting are the same as those used in oil painting, and are washed and prepared with equal care.

Mixing.—The prepared colouring matter and the base are ground together in proportions suited to the desired tint. A gradation of tints is obtained in the following manner: A portion of colour is divided into as many parts as there are to be tints. To one of these, one portion of base is added, to the next two portions, to the next three, and so on. It is obvious that in this way any number of tints may be obtained.

A mucilage of gum arabic, or gum tragacanth, is usually employed to make the paste which is to form the crayons. Other substances, such as skimmed milk, barley-water, and powdered sugar-candy, are sometimes brought into use.

When the paste is to be made into crayons, it is placed upon absorbent paper that superfluous moisture may be removed, and then rolled into small cylinders about 2½ in. long. Air bubbles are prevented by subjecting the paste to strong pressure.

The crayons are dried slowly, and are then found to be covered with a kind of bloom. This is removed by fine glass-paper, and the colour of the crayon is revealed.

(4) **Crayons for Drawing on Glass.**—Melt together equal quantities of asphaltum and yellow wax; add lampblack, and pour the mixture into moulds for crayons. The glass should be well wiped with leather, and in drawing be careful not to soil the glass with the fingers. In trimming these crayons, if the edge be bevelled, like scissors, the point may easily be rendered very fine.

Tailors' Crayons.—These are composed of French chalk (silicate of magnesia) and not ordinary chalk which is carbonate of lime. The French chalk should be ground up, and a little china clay added to make the finished crayon stiffer and less liable to break. Mix with water to a stiff putty, not a paste, then knead it preferably in a machine. The material is then pressed into moulds, these being afterwards put in a hand press. The moulded pieces are then carefully removed and laid on trays, in a warm atmosphere, to dry.

* * *

DAMPNESS IN BUILDINGS,

PREVENTION OF.

AT the Hornsey Museum of Sanitary Appliances there is a good and practical method adopted for showing the effectiveness of different ordinary damp-courses. It consists of sections of 14½-in brick walls properly built with ordinary mortar, and having damp-courses arranged as shown in Fig. 127. These examples of brickwork stand in a shallow trough which is kept perpetually supplied with water, so that the walls that these examples represent are subject to a very severe test to prove the efficiency of the damp-courses. The foundation walls of houses are, in the general way, only damp occasionally, and rarely rest in water day after day as these examples do. It will be noticed that the first wall, commencing from the left, having no damp-course of any kind, is not only damp but saturated to the top. The distance that water will travel up a wall which has nothing to check it, depends on the porosity of the bricks. Very porous bricks are not specially favourable to the water creeping up them, nor are bricks which are particularly hard and dense. It is what we may call the ordinary brick that admits of the action occurring most freely. The action is that of capillary attraction, such as can be seen with a piece of sugar or salt which rests in a little liquid. A peculiarity is, that when once the damp has risen by this action, it does not come down again when the supply ceases; it remains until it is dried out.

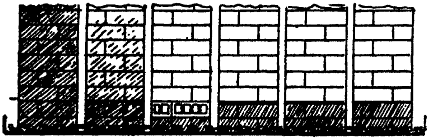

FIG. 127.

In the second example from the left, in Fig. 127, there is a damp-course inserted, this being of tarred roofing felt. It was a good quality felt and carefully and properly inserted, but has proved a failure, though not to such a marked extent as that in which no damp-course was provided. In the third example a vitrified (glazed) stoneware brick course is used, and proves to be a perfect barrier, but care is needed in using these bricks, particularly in jointing them, so that water cannot creep up between. There are several kinds of damp-proof tiles or bricks, some being keyed together, others with tongue and groove joints; and they should be laid in cement, or in asphalt and sand. The holes through them can be utilised for ventilating under the floors. The fourth example is also proof against damp rising by capillary attraction, the damp-resisting course being two slates laid in cement. This is used very largely and considered good practice, the slates being laid so that the slates of the top course properly cover the joints of the course beneath. Slates laid in this way and carefully bedded in cement will last sound unless there is a settlement in the foundations, in which case any rigid kind of damp-course might be destructively injured. There need be no hesitation felt in using this arrangement of damp-courses, but a course of single slates is practically useless.

The fifth example introduces a material which is being largely used, and shares a deal of favour for its excellent damp-resisting qualities. This is mastic asphalt, and for foundation work is mixed with sand, and applied hot. For roofs, tanks, reservoirs, or the outsides of underground conveniences, where there is a likelihood of trouble with water, it should be applied in two layers ⅜ in. thick, or under exceptional circumstances each layer should be ½ in. For ordinary damp-courses one layer ½ in. thick is satisfactory. There is a slightly elastic nature to asphalt which makes it able to bear strains which though only slight might rupture slate, cement, or stoneware. The last example has a damp-course of 7-lb. sheet lead, the most excellent damp-resisting course that could be devised, but unfortunately it is about the most expensive that could be used. Sheet lead of 5 lb. or 6 lb. thickness could be used if desired, but 7 lb. is best; it is not necessary to joint the ends where they meet by solder, but let them be turned up and welted.

In Fig. 128 is illustrated the most usual way in which a damp-course appears, viz. about 6 in. above ground level, in which case the floor line is above ground also, as the damp-course should always be beneath the lowest timber. This shows a double slate course, while Fig. 129 shows one of asphalt with the addition of an air brick and passage to ventilate the floor joists and prevent dry-rot. It might have been mentioned earlier that in cases of buildings which are without damp-courses or have them of an imperfect kind, there is no simple remedy that can be adopted. Several devices have been brought forward supposed to overcome the trouble, but whether it be a paint, a cement, or

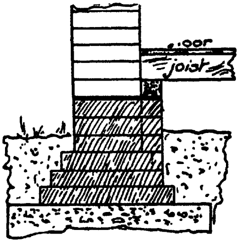

FIG. 128.

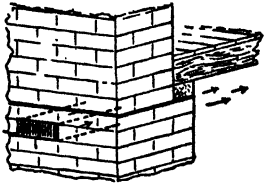

FIG. 129.

other material to coat the wall with, the fact remains that the damp is still there, unchecked and injurious. In many cases it will in time work through the compound that the wall is coated with, in others the continued damp will injure the building by its action on the brickwork. Bricks to withstand water for any length of time have to be carefully picked, for unless sufficiently burned they will disintegrate. On this account it is highly important that foundation bricks be fully fired, overfired would not matter, to withstand the moisture successfully.

When a damp wall has to be dealt with, the proper remedy is to cut out the brickwork and insert a damp-course. Studding the wall, so that the plaster stands away 2 or 3 in., is but a very limited kind of remedy, and in no way alters the fact that the wall remains saturated with water. In some cases studding would prove an expensive remedy, for with bricks that have a substance favourable to moisture rising in them, the damp has been known to ascend as high as 32 ft. This was distinctly traced as coming from the ground, and not from any other source. A rather dense brick is more favourable to this, as it does not permit the water it contains to evaporate or dry out quickly, and therefore the water rises higher than in brickwork which gives the moisture up to the air freely. That the presence of the water is very real can be judged by the fact that a cubic foot of ordinary brickwork can absorb and hold 10 pints of water.

In shops and many buildings the floor line is on a level with the ground or thereabouts, and it becomes impossible to keep the damp-course above ground level without some special arrangement to this end. Fig. 130 is the plan usually adopted, and it practically amounts to making a small dry area around the house. The thick black line just below the level of floor joists shows the damp-course, but it is understood that this applies to buildings that have no basements, or to the parts of buildings where the basement does not come. The area, as it may be called, is formed of 9-in. brickwork in cement, and will be found to fulfil the purpose intended well.

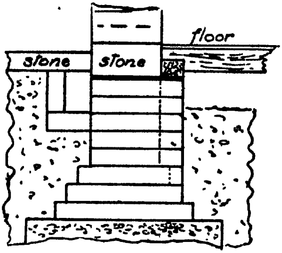

FIG. 130.

In cases of basement rooms—rooms having their walls below ground level—a very different plan has to be adopted. With these the best course to adopt is to make a proper dry area of sufficient depth, but if this is impracticable, the use of asphalt must be resorted to, as Fig. 131. The outer wall, it will be seen, has two damp-courses to it, one in the usual position, about 6 in. above ground level, the other just below the floor timbers, as previously recommended. The object of these two courses is plain, but to make the lower one successful there must be an outside damp-course or lining to join the two, and prevent moisture passing through the wall laterally.

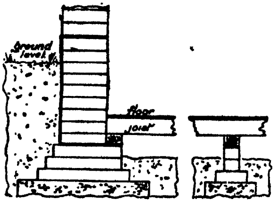

FIG. 131.

Asphalt requires to be applied to a smooth surface, so the wall should be carefully rendered first, and the asphalt then applied about ¾-in thick, in two coats breaking joint. The joints of the brickwork should be carefully raked out and "primed" with asphalt to ensure good work. If put outside, as shown, the work proves quite successful the object being, of course, to keep the wall of the basement rooms dry and the rooms healthy, the same as those that come above ground. A word of caution is desirable as to the asphalt itself; this material of ordinary good quality is excellent as stated, but it must not be supposed that tar or vegetable pitch mixed up with sand or lime will answer as well. Do not try a bad imitation of asphalt for this work. Asphalt is a mineral pitch, and its use for protecting surfaces from air or water can be traced back to the earliest times. What is considered to be the best for general results has limestone powder in its composition, about equal parts with the asphalt, and to this mixture is added between 2 and 3 times as much sand. The proportions that are given by an engineer of experience are:—

Asphalt	16
Limestone powder	15
Sand	69
	100

This makes a compound that will bear both hot and cold extremes of temperatures.

A final example of the use of asphalt as a preventive of water rising through brickwork, applies to an instance where there is an actual rise of water in the subsoil accompanied by some degree of pressure. In such a case there is the likelihood of the basement floor being burst up, and no damp-proof substance would be able to resist this force. Where water rises in a subsoil above the level of a basement floor there will be a pressure exerted under this floor in exact ratio with the height the water rises above it. Approximately this pressure will be ½ lb. per sq. in. for every 12 in. the water rises above the floor, and remembering how very many sq. in. there are to a floor of fair size, the pressure will be found considerable for a very small rise of water. Sometimes it may be that there is a lake, moat, or reservoir beside the building, in which case the pressure would act the same as if it were subsoil water, unless, as in the case of a reservoir, its bottom was lined with some impervious material.

To withstand this upward thrust to a floor an inverted arch is carried across from wall to wall, and this is laid in asphalt on the under side to make it both damp and waterproof. The arch is filled in with coarse concrete, finished off with finer material at top, and the upper surface may or may not be given a 1-in. coat of asphalt also. It is essential in this arrangement to put two horizontal damp-courses to the walls as shown, and as described with the last example, and there must be the vertical lining of asphalt, which joins the upper and lower courses. One important thing in relation to the use of asphalt on brickwork is that the brickwork should be dry, and in instances where this material is applied to single loose bricks it is advantageous to make them moderately hot first. In no case must the bricks or brickwork be damp. This is, of course, exactly the reverse of what is proper when applying ordinary cement.

Hollow Walls.—What is probably the most effective and simple means of preventing the interior surfaces of walls from becoming damp is to build the foundation walls hollow. This is to carry up two distinct walls with an air space between them, but for various reasons it is desirable that they be bonded together. Were they not united by bonds or ties, then two 9-in. walls would scarcely give the stability of one 14½-in. in supporting the brickwork above; but when properly tied they afford all the support that a solid brick wall of the same thickness would do. In regard to the thickness of brickwork, this pair of walls may be both 9-inch; or what is commonly done is to make one 9-in. and one 4½-in., the usual practice being to put the thinnest one outside. The space between the walls, the hollow part or air chamber, would be effective if not more than 1-in., but with the utmost care this narrow gap would get stopped with droppings of mortar and débris. Three inches is considered the least practical space, and some consider that 4 in. should be the minimum. With either of the latter it is best to leave openings at the bottom to clear out mortar droppings and fallen matter when the wall is finished, after which the opening may be closed.

The ties used for hollow walls are of two materials, brick and iron, but unless the brick be of a kind specially made for this purpose, the iron should be used. Ordinary stock bricks offer no resistance to the passage of moisture across the hollow space. and although stock bricks coated with gas tar, or with asphalt, are used sometimes, it is not a commendable plan. The coating of impervious material will prevent the water passing through the substance of the brick (as it would do otherwise), but notwithstanding this, some water will pass along the surface from one wall to the other.

Fig. 132 illustrates a tie, or bonding brick, designed expressly for this purpose, and made of glazed vitrified earthenware. As will be seen, these are made to extend from outside to outside of wall, or can be had to only reach within a half brick of the face, so as to allow for the outside bond. The ends of these bricks are wedge-shaped, which gives them a firmer hold in the wall, and the holes in the centre allow the greater part of the water to fall down below. The serrated edges quite prevent any moisture creeping along the sides of the bricks, for although it might travel along a straight edge, as it does with the tarred stock brick just referred to, it cannot pass this irregular surface, but drops from the points.

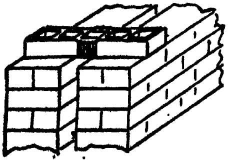

FIG. 132

Fig. 133, showing another brick tie, is considered to be a better designed one than the two last, and it will be seen it does not interfere with the bonding of the ordinary outside bricks of the wall. The nearer wall of the illustration is the inside one, the tie brick being fixed so that moisture from the outside would have to travel up hill to reach the inner wall, and this it fails to do of course. This brick, when made short as shown, has a 2¼-in. bearing surface at each end, which even with 4½-in. walls allows a short header to come in front. The only object in keeping the tie brick short in this way is to overcome the objection that has sometimes been raised, that the ends of the brick when visible do not match the surrounding brickwork and mar the appearance of the wall. For those that prefer the tie-brick longer, they are made with 4½-in. bearing each end, or 4½-in. one end and 2¼-in. the other; in the latter case the short end rests on the outer wall. When building, it is a good plan to lay strips of wood on the bonders to catch the mortar droppings, the wood strips being raised course by course as the work proceeds.

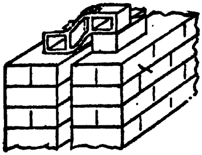

FIG. 133.

In Fig. 134 are the two forms of iron ties for hollow walls. Each of these is successful in preventing the passage of water from the outer to the inner brickwork, and a number of people use them in preference to bonding bricks, but this is in many cases influenced by the cost. A bonding brick of proper make and quality is practically imperishable, but the same cannot be said of an iron tie, however well it may be protected, though, of course, it would take a long time to bring about its destruction, and before then the wall would be firmly settled, and probably need no ties of any kind. The preservation of iron ties, wrought or cast, is generally effected by well tarring them or by galvanising. Paint is scarcely sufficient, and a good coating of—or soaking in—hot pitch is better than tar. When treated with pitch or tar, they may be well dusted with fine sand as a further protection.

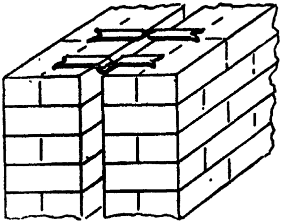

FIG. 134

The usual distances at which wall ties are placed, is every sixth course in height, and about 2 to 3 feet apart. In cases, however, of walls which bear the jar and vibration of machinery, etc., they had best be put every 3 or 4 courses, and every 18 in. to 2 feet apart. Some care should be taken that the ties do not all come precisely over one another, but they should be placed so that the water dripping from the upper ties does not come on those below, as far as possible. A large number of different iron ties are used, some being made by the builder just to suit his convenience. These are usually a short length of light bar iron, bent at the ends for the required bond; but plain flat iron, whether fixed flat or on edge, will by no means effectually prevent water passing from one wall to the other.

THE DENDROMETER.

THERE are various methods of ascertaining the heights of trees, all more or less satisfactory; but the simplest and most efficient contrivance that has come under our notice is a little instrument invented by Kay. It consists of a square board (Fig. 135), having its sides 9½ in. long. On the sides of this square, parallel lines are drawn at right angles to the edges. The square is attached by means of a pivot and clamp screw to a stout iron-shod pole about 4½ ft. long—a convenient height for taking tree measurements.

The instrument is constructed on the principle which applies to all right-angled triangles. The side A B (Fig. 135) is termed the base-line, and corresponds with the horizontal line from the tree or other object intended to be measured, to the foot of the observer. The lines running perpendicular to the base line represent the altitude or height of the object either in feet, links, or yards, according to the scale by which the base line is measured. The height of any given tree is indicated on the face of the dendrometer at the point where the plumb line (suspended from the point A) intersects the perpendicular line corresponding with the distance on the base line from the centre of the trunk of the tree to the observer. The figures along the top and bottom of the instrument show the number of divisions corresponding to the lines of altitude intersected by the plumb line.

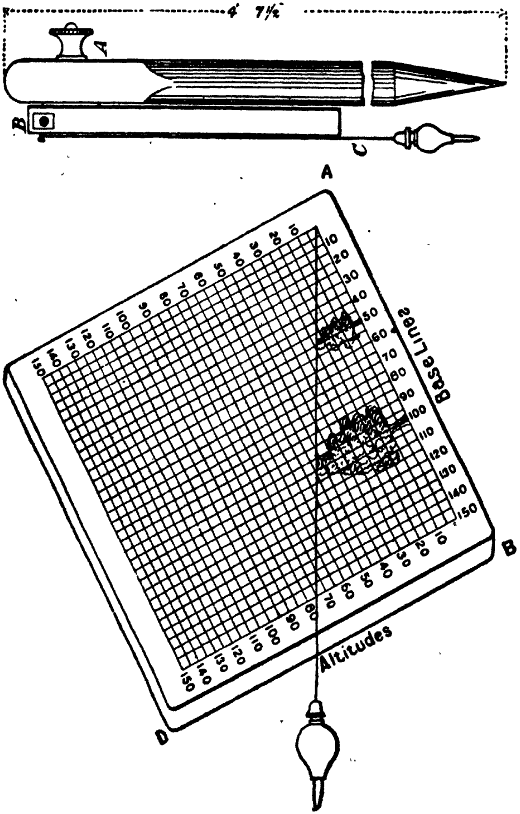

FIG. 135.

Each line of altitude represented on the instrument corresponds with a unit of the scale employed, whether this scale be in feet, links, or yards. The base line is marked only at every fifth unit, thus, 5, 10, 15, 20, and so on. Whatever standard of measurement is fixed upon, whether it be in feet, links, or yards, for the base line, it is of course understood that the lines of altitude must be fixed to the same scale. The divisions on the face of the instrument are 150, but if at any time it be desired to ascertain the height of an object above 150 ft., the divisions of the instruments must be termed yards, when, of course, a height of 450 ft. can be measured.

The mode of using the dendrometer is as follows: Suppose the object to be measured be a tree. The operator must first place himself at such a distance from the tree that the extreme top of it can be distinctly seen. Note must then be made of the distance from the centre of the bole of the tree to the staff of the dendrometer. At this point (where the operator stands) the staff of the dendrometer is to be fixed in the ground. Then setting the instrument in the direction of the tree turn the square face of the instrument (which works on a pivot fixed at the upper angle) until the plumb line falls direct upon the line A B (Fig. 135). Fix the square in this position by the clamp screw, and then look through the "sight" (the perforation running through the square from C to A, Fig. 135), and mark the place on the tree where the line of sight cuts the tree, as at B in Fig. 136. This point (B) will give the level corresponding to the height of the observer. Next loosen the clamp screw and turn the square until the line of sight cuts the extreme top of the tree, then tighten the clamp screw again. The plumb line will then be seen to make a triangle with the base and altitude lines, as shown in Fig. 135. The height of the tree will be indicated by the number of the line of altitude, which is intersected by the plumb line, on the base line corresponding with the measured distance from the tree.

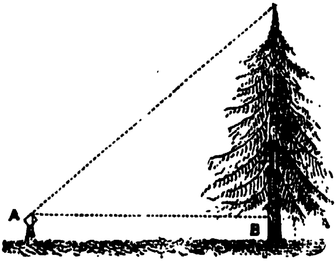

FIG. 136.

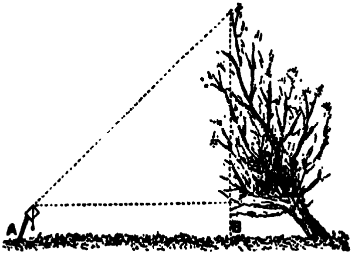

FIG. 137.

The diagram (Fig. 135) shows clearly what takes place during an observation. Suppose the base line from the centre of the tree trunk to the observer measures 50 ft., and after "sighting" the top of the tree the plumb line falls over the square in the manner indicated in the diagram (the upper figure), the height of the tree measured would then be 25 ft. Again, if the base line measured 100 ft., and after "sighting" the topmost point of a tree, the plumb line fell across the square, as in the lower figure in the diagram, the tree would be 50 ft. in height. Of course, in every case the height from the ground to the observer's eye must be *added* to the height read on the instrument.

In measuring reclining trees or other objects, care must be taken not to measure the base line from the centre of the tree trunk, but from the point on the ground perpendicular to the highest part of the tree. This point may be ascertained by holding a plumb line between the eye and the tree, and marking on the ground the place thus indicated, as at B, Fig. 137. On finding this point perpendicular to the highest part of the tree, the observer may proceed as in the preceding instructions. It will thus be seen that in measuring objects not exactly perpendicular, some care is necessary in the operation, or the measurements will be inaccurate. In the case of ascertaining the height of an object, as for instance that represented in Fig. 137, if the base line were measured from the centre of the bole, instead of from the point B, the observed height would be too great. In short, if the base line were measured from the centre of the bole on the side to which the tree is leaning, it would give too great a height, and on the other hand, if the base line were measured on the side the tree is leaning from, the height so ascertained would be less than the true height of the tree.

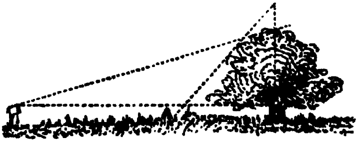

FIG. 138

In measuring the height of round or flat-topped trees, the observer must choose a station sufficiently distant, so as to fully see the highest part. If viewed too near, as at A in Fig. 138, it is impossible for one to see the highest part of the tree, and the result is that the height is greatly increased. Therefore, in order to avoid such errors, the object should be viewed as far back as possible, so as to obtain a view of the highest point right over the true perpendicular, or, in the event of this not being possible, the perpendicular and height of some definite point may be ascertained as in Fig. 137.

The height of any part of a tree or other object may be ascertained by subtracting the result of one observation from that of another.

This instrument possesses many advantages. It is simple, no calculation being required; the height of any tree or other object can be ascertained at any convenient distance, and by it the height of any portion of a tree, such as the height of the trunk, can be ascertained from one station. It is, moreover, light and portable, not its least recommendation for an instrument of this kind.

* * *

DENTAL PORCELAIN.

THE compositions used for dental porcelain are : (*a*) A body composed of 373 gr. felspar, 62 gr. quartz, 23 gr. kaolin, and 1·5 gr. native titanium oxide. (*b*) An enamel consisting of 93 grm. felspar, 6 to 25 cgrm. of sponge platina, and 4·6 grm. of flux. (*c*) A flux composed of 125 gr. of quartz, 31 gr. of borax, and 31 gr. sal tartar. (*d*) A gum frit of 64 mgrm. of oxide of gold, 31 grm. felspar, 12 grm. of flux. (*e*) A gum enamel composed of 31 gr. gum frit and 93 gr. felspar. (*f*) A yellow enamel of 64 mgrm. of native titanium oxide, 128 mgrm. gold frit, 96 cgrm. of starch, and 31 grm. felspar.

In the process of manufacture, the quartz and felspar are first heated to redness and then quenched with cold water, and ground after the removal of impurities. The compositions are mixed with water and worked into a dough-like consistency. This is then moulded into the desired shape in moulds so constructed as to receive the platina pins which are inserted during the moulding process. The top of the mould is then put on, and the matrix placed under a press which compacts each separate mass. They are then dried slowly, removed from the moulds, and carefully trimmed and fettled to the required shape. The teeth are then placed on beds of coarse quartz sand, on trays or slide of fire-clay, and placed in a kiln for firing, the burner being able to determine by experience from the appearance of the teeth, when the firing is completed.

* * *

DEW PONDS.

DEW-PONDS depend for their operation on the complete heat insulation of a water-containing surface from the surrounding ground. This is most readily effected by interposing a thick layer of straw, which must be kept perfectly dry, between the ground and the puddled clay surface forming the bottom of the pond.

The operation of forming a dew-pond is as follows : The dimensions of the finished pond having been settled an excavation is made at least a foot larger in every way, in this hollow is placed a thick coating of dry straw, which is in its turn covered with a layer of finely-puddled clay with an upper surface closely strewn with stones. The puddled clay is carried well over the edge of the straw to prevent surface water from penetrating to the latter. The pond is now complete and will at once commence to fill, and, if properly constructed, will keep filled in the hottest summer.

During the daytime the exposed ground will store up a considerable amount of heat, but the ground under the pond is not only protected from the sun by the straw, but is still further chilled by the evaporation of the moisture from the puddled clay, so that at nightfall there is a heavy condensation of moisture from the warm air, which condensation is greater than the daily evaporation and gradually fills the pond.

It should be noted that a dew-pond should be carefully fenced against cattle, as their hoofs will very soon destroy the layer of puddled clay, and admit water to the straw.

The use of these ponds on the dry waterless downs of the south of England is evidence of their value and there is no doubt that the principle of their operation is capable of application in high-lying waterless districts in other parts of the world.

DIPPING AND COLOURING BRASS.

(*And see* LACQUERING.)

Dipping.—During the process of stamping brass, it must be softened or tempered from time to time. At the end of the process, it has lost its colour, owing to the formation of a coating of oxide during the tempering operations. This coating is easily removed by plunging the metal into nitric acid, and then washing it thoroughly with water. A brilliant metallic surface is thus produced, ready to receive the customary layer of lacquer or varnish. This cleansing process, is known as "dipping." If the brass contain any impurities, dipping will not impart to it a brilliant surface. The colour produced by dipping varies according to the strength of the acid; this is due, it is believed, to the fact that the metals constituting the alloy are acted upon to a greater or less degree by acids of different degrees of dilution.

The operation of dipping is performed in the following way: The object, with a black coat of oxide, is plunged into nitric acid containing 1 part of the pure acid to 7 or 8 of water. It is allowed to "pickle" as it is termed, in the acid solution until the crust can be detached by rubbing the surface of the metal gently with the finger, when it is withdrawn, and washed immediately in water. It is next dipped into a much stronger acid solution, where it remains until the "curd" appears, or until the surface of the metal is entirely covered with minute bubbles of gas. This solution should be about twice as strong as the one previously used. The brass must then be washed with a plentiful supply of water, and roughly dried in cold sawdust. It is afterwards dipped, with the particles of wood still adhering to its surface, into strong nitric acid, where it remains only a few moments, then rinsed with a little water, and immediately afterwards thoroughly washed with water containing argol in solution. It is finally dried in hot sawdust, after which the surface is ready for the lacquer or varnish.

Another dipping bath, which has been recommended, consists of hydrochloric acid and alum. It is said, however, that the lustre given is much duller and of a greenish hue, in comparison with that given by strong nitric acid. When dipping articles, have a bath of whiting and water close to the acid-bath. When the article has been dipped 4 seconds, remove it, and *instantly* plunge into the whiting and water, which removes at once all the acid and oxide, and it comes out a beautiful dead-gold colour, requiring to be only dried, warmed, and lacquered. Should the first dip be not sufficient, repeat the process, and end by a dip just in and out again quickly, having previously cleaned the article in water and dried it. Don't put it into the acid wet, because some parts being wetter than others, the acid will attack them unequally, and the result may be a cloudy mottled appearance on the surface. Never use a pair of iron tongs or forceps for holding the work when dipping; either suspend it from a brass wire, or make a pair of tongs out of a piece of $\frac{3}{4}$ by $\frac{3}{16}$ in. brass, something like a long pair of sugar-tongs. If obliged to use this process indoors, get a draught to carry away the brown fumes; if you have a fireplace not in use, make a board to fit it exactly, and at a convenient distance from the bottom cut a hole in it about 6 in. square; place the acid-bath close in front of this, and the air rushing through will carry the hurtful fumes up the chimney.

Ornamenting Brass Surfaces. A mottled appearance is produced on brass by a "spotting" machine. A fair imitation can be made by the flat end of a piece of slate pencil. Put a piece of wood or metal, with a hole in it the size of the pencil, upon the piece of brass you wish to spot, and, having dipped the end of the pencil in water, place it in the hole and turn it round a few times, when it will form a grey spot.

A dead appearance, called by the French *mât*, may be obtained by plunging the articles in a mixture of strong nitric acid 200 parts; sulphuric acid sp. gr. 1·845, 100; common salt, 1; sulphate of zinc, 2. The articles will require thorough rinsing. Another recipe, suitable for large work, consists of: 3 parts nitric acid, 1 sulphuric acid, 1 water, ½ zinc sulphate. Dip the articles and rinse, again dip and rinse until the earthy yellowish dulness gives way to a clear *mât*, without earthiness.

For frosting small brass-work, fasten a circular scratch-brush, made of very fine brass wire, on the lathe, and having previously scoured the brass with strong pearlash lye, hold the work against the revolving brush, which must be driven at a good speed.

Holtzapffel introduced the following style of ornamenting flat surfaces: The work (after being filed, scraped, and passed over with Water-of-Ayr stone) is clouded with a piece of charcoal and water, by means of which the entire surface is covered with large, curly marks, which form the ground. The curls resemble an irregular cycloid pattern, with loops of ½ in. to 1 in. in diameter, according to the magnitude of the work. Similar but smaller marks are then made with a piece of snakestone, bluestone, or even a common slate pencil, filed to a blunt point. The general effect of the work much depends on the entire surface being uniformly covered; with which view the curls should be first continued round the margin; the central parts are then regularly filled in; after which the work is ready to be varnished.

Brightening and Colouring Brass.—The work to be brightened and coloured is first annealed in a red-hot muffle, or over an open fire, allow- the cooling to extend over one hour; the object of the heating being to remove the grease or dirt that may have accumulated during the process of fitting. Soft soldered work, however, must be annealed before fitted together, and afterwards boiled in a lye of potash; this is also done with work having ornamental surfaces. Next, it is immersed in a bath of diluted oil of vitriol or aquafortis, which may be made with two or three parts of water, and one of acid; but the old acid that contains a small quantity of copper, in solution, is frequently preferred. The work is allowed to remain in this liquid for one or two hours according to the strength of the acid; it is then well rinsed in water, and scoured with sand applied with an ordinary scrubbing brush, and washed. The pickling bath is made by dissolving one part of zinc in 3 parts of nitric acid of 36° B. in a porcelain vessel, and adding a mixture of eight parts of nitric acid, and eight parts of oil of vitriol. Heat is then applied, and when the liquid is boiling, the work is plunged into it for half a minute, or until the violent development of nitrous vapour ceases, and the surface is getting uniform. Then it is plunged into clean water, and well rinsed, to remove the acid. The ordinary dark greyish-yellow tint, which is thus very often produced, is removed on immersing the work again in aquafortis for a very short time. Then it is plunged into clean or slightly alkaline water, well rinsed to remove the acid, and plunged into warm dry beech or boxwood sawdust, and rubbed until quite dry. To prevent the action of the atmosphere it is lacquered; if a green tint is to be produced, the lacquer is coloured with turmeric. A dark greyish but agreeable tint is obtained by immersing the work previously in a solution of white arsenic in hydrochloric acid, or in a solution of bichloride of platinum, under addition of some vinegar, or rubbing with plumbago.

◆

DISINFECTANTS.

Recipes for Disinfectant Preparations in Common Use. —*Atomizer Liquid for Sick Rooms.* Parts by weight, eucalyptol, 10; thyme oil, 5; lemon oil, 5; lavender oil, 5; spirit (90 per cent.), 110. For use put a teaspoonful in a pint of water.

Carbolic Powder (Strong).—1 cwt. slaked lime in fine powder, 2 gal. 75 per cent. carbolic acid, colour with aniline dye, and then pass through a moderately fine sieve and put into tins or casks, and keep air-tight.

Disinfectant for the Breath, etc.—A very weak solution of permanganate of potash is an excellent disinfectant for light purposes, such as rinsing spittoons, neutralising the taint of diseased roots of teeth, cleansing the feet, and keeping the breath from the odour of tobacco-smoke. Permanganate is not poisonous.

Disinfecting and Fumigating Oil.—Melt 7 lb. naphthalene by gentle heat, then (away from fire) mix in 10 qt. of rosin spirit previously warmed. Add 2 fl. oz. of cassia oil. This may be used as an insecticide.

Disinfecting Fluids.—(*a*) 1 cwt. resin, 16 gal. caustic soda lye, 18° B., ½ gal. black tar oil, 2 lb. nitro naphthalene, dissolved in boiling water (about ½ gal.). Melt the resin, add the caustic lye, then stir in the tar oil and add the nitro naphthalene. (*b*) 1 oz. camphor, 12 oz. carbolic acid (75 per cent.), 10 dr. aqua ammonia, 8 dr. soft salt water. To be diluted when required for use. (*c*) (White.) 40 gal. water, 3 gal. turpentine, ½ gal. ammonia, 14 lb. carbolic crystals, 2 gal. caustic lyes, 60 lb. white sugar dissolved in 40 lb. water. Heat water to boiling, and add first turpentine, next ammonia, and then carbolic crystals. Stir well up until thoroughly dissolved, and add lyes and sugar solution.

Disinfecting Powder.—That of one famous maker which for many years has been to the front is said to consist of 100 parts sulphate of iron, 50 parts sulphate of zinc, 40 parts oak bark powder, 5 parts tar, 5 parts oil.

Disinfecting Rooms.—Some prefer to boil 2 or 3 lb. of soft soap in 4 gal. of soft water, and add about a pint of carbolic acid. Others use a solution of permanganate of potash, whilst in some cases chloride of lime, chloride of soda, or sulphate of zinc are the chief agents employed.

Exterminating Vermin in a Room.—(*a*) When lice, fleas or bugs infest a room it is necessary to strip the paper off the walls and loosen fixtures, as far as possible, to let the disinfecting fumes get to every point. After this, every crevice and opening must be closed by pasting paper over, including fire-place openings, crevices around window sashes, etc., and when the operator has set the disinfecting material into action, he must close the door, and paste over all cracks around outside it, the keyhole, etc. If sulphur is to be used, the air of the room should be moist, and this may be effected by a saucepan of water boiling over a spirit lamp or oil stove. The roll sulphur is broken up into small pieces, allowing 1 lb. for each 1000 cubic feet of space in the room, and after being put in an iron pan, it is wetted with methylated spirit and set on fire. The operator having seen the sulphur start burning, then leaves the room. The pan must be stood on bricks and sand, or some such provision be made, to prevent the floor catching fire. (*b*) Chlorine gas is very fatal to verminous life and may be produced by putting chloride of lime in a pan and letting hydrochloric or sulphuric acid run on to it. The quantity should be 2 lb. of chloride of lime and 1 lb. acid to each 1000 cubic feet of space. The difficulty of using this lies in the rapid production of gas, and some provision must be made to retard this, while the operator leaves the room and pastes over the crevices in the door. One plan is to arrange that the acid merely drips on to the lime, while a better plan is to let the acid drip into a very small cup first, so that not until the cup overflows will the acid touch the lime. In all cases the room should be left closed a day and a night or a little longer. When opening the room, the breath should be held while windows are thrown open and the paper in front of the fireplace torn away, then the room should be left to clear a little time.

Formaldehyde, for disinfecting Books, Papers, and various articles.—This substance has the property of penetrating paper even when folded in many layers, especially at a temperature of 85° to 120° F. The degree of penetration and general efficiency depend on the method of using the gas. Letters and paper in closed envelopes are disinfected in 12 hours, books 24 hours, at a temperature of 120° F., when 70 c.c. of formochloral —17·5 grm. of gas—is used per cubic metre of space. Books must be stood on end that the gas can enter between the leaves. Bacilli of typhoid preserve their vitality longest on unsized paper and filtering paper.

In using formaldehyde on general goods it is always best to subject them to a mechanical cleaning, such as scrubbing first, as this gives the gas a better chance of acting perfectly. When used for disinfecting casks, the formaldehyde should be given time to act before steam is turned into the casks, for if steam follows too soon, it simply drives the disinfectant out. Failing this, the disinfectant and the steam should be used together.

Formalin—(Formaldehyde, CH_2O, in aqueous solution)—is a disinfectant that coagulates all albuminous matters, and, consequently, destroys bacteria by chemical action. It also, of course, coagulates substances on which bacteria thrive. It is a very volatile substance, its fumes being particularly penetrating and pungent; it should not be breathed, as it attacks the mucous membrane. It is usually obtained as a 40 per cent. solution with water. It may be sprayed in a room (the operator being outside), or a number of saucers with the solution in them may be placed in the room and left to volatilise. All cracks and openings in the room should be previously pasted over inside with strips of paper, also those around the door outside after the operator has come out and closed it.

General Odourless Disinfectant.—10 oz. alum, 10 oz. sodium carbonate, 2 oz. ammonium chloride, 1 oz. zinc chloride, 2 oz. sodium chloride, hydrochloric acid, 1 gal. water. Dissolve the alum in ½ gal. of boiling water, and add the sodium carbonate, next add hydrochloric acid until the precipitate formed is dissolved. Dissolve the other salts in water and add. Finally add water to make the whole 1 gal., and filter. In use this is diluted with 7 parts of water, i.e. 1 qt. with 7 qt. of water makes 2 gal. for use.

A Germicide of undoubted efficiency is corrosive sublimate, but this is one of, if not *the* deadliest of poisons. About 80 gr. of sublimate to a gal. of water is suitable for spraying into awkward corners, crevices, etc., and this solution will serve to wash woodwork (painted or plain), floors, and even furniture. The greatest care must be taken not to let it touch the hands, as any slight cut or abrasion may lead to poisoning.

Non-poisonous Fluid Disinfectants. (*a*) Dissolve 2 lb. caustic soda in 12 lb. water, add 7 lb. powdered rosin, then boil until the rosin is quite dissolved, stirring occasionally. Add 4 lb. soft soap, and boil down to nearly one half. Let cool, then add 37 lb. crude rosin spirit, stirring well. Keep covered until cold, then put in bottles and cork them. This amounts to being a rosin soap. (*b*) 4 lb. permanganate of soda crystals dissolved in 20 gal. of water. This is much like Condy's fluid.

Paris Salts.—50 parts zinc sulphate, 50 parts ammonia alum, 1 part permanganate of potash, 1 part lime. These are fused together, mixed with a little calcium chloride and perfumed with thymol.

Pastiles for Fumigating. — Gum arabic, 2 oz.; charcoal powder, 5 oz.; cascarilla bark, powdered, ¾ oz.; saltpetre, ¼ drachm. Mix together with water, and make into shape.

Pink Carbolic Powder.—(*a*) 6 gal. of liquid carbolic acid is sprinkled over a mixture of 5 cwt. of an earthy base and 15 lb. of red ochre. For the earthy base kieselguhr (infusorial earth or fossil meal) is good, but any inert inorganic earthy substance will serve. Thoroughly mix to give a uniform nature and colour. Soluble creosote (containing carbolic acid) is sometimes used instead of carbolic acid. (*b*) Use calcined gypsum instead of fossil earth, mixing it with carbolic acid or creosote (and red ochre) like a mortar. (*c*) Use well slaked dry lime for the earthy substance.

Pink Sanitary Material.—Used at live-stock shows. Take 14 gal. of sanitary carbolic fluid, stir in 10 qt. of turpentine, then add 25 gal. water and stir into an emulsion. Add about 2 lb. of any aniline red soluble in water (magenta is commonly used), then sprinkle the whole, by a water-can, over 10 cwt. of pine sawdust (not too fine), turning well with a shovel all the time. If preferred the colour can be dissolved in a tank of water and the sawdust stained in this before it is treated with the disinfectant.

Pink Carbolised Sanitary Powder. 6 oz. powdered alum, 5 lb. powdered green copperas, 5 lb. powdered red lead, 12½ lb. carbolic acid, 1½ lb. spirits of turpentine, 10 lb. Calais sand, 60 lb. slaked lime. Mix carbolic acid with turpentine and sand, then add the other ingredients, lastly the slaked lime, and, after mixing, pass through a sieve. It is advisable to use lime that has been slaked some time.

Crimson Disinfecting Fluid. See *Non-poisonous* (*b*).

Blue Sanitary Powder.—2 lb. powdered alum, 12 oz. oil of eucalyptus, 6 oz. rectified spirit of tar, 2 oz. rectified spirit of turpentine, ¾ oz. common ultramarine blue, 14 oz. common salt. Mix alum with about 3 lb. of salt in a large mortar, gradually add oil of eucalyptus and spirits, now put in the ultramarine blue, and lastly the remaining salt, mixing all well, and pass through a sieve.

Platt's Chlorides.—(*a*) 6 oz. aluminium sulphate, 1½ oz. zinc chloride, 2 oz. sodium chloride, 3 oz. calcium chloride, water to make 2 pints. (*b*) The following resembles the proprietary article: 4 oz. zinc in strips, 2 oz. lead carbonate, 1 oz. chlorinated lime, ½ oz. magnesium carbonate, 1½ oz. aluminium hydrate, ½ oz. potassium hydrate, 16 oz. hydrochloric acid, 16 oz. water, whiting. Dissolve the zinc in the acid, then add the other salts in the order named, letting each dissolve before the next is added. When all are dissolved add the water, and after about 2 hours, add a little whiting to neutralise any excess of acid. Filter.

Sanitary Carbolic Fluid.—Boil 8 lb. common caustic soda in 5 gal. of water until dissolved. Add 3 lb. of common rosin, and boil until saponified (of the nature of soap) and all is quite dissolved, seeing that boiling over does not occur, as is likely to happen as it froths very much. Continue boiling until reduced to 6 gal., then add 8 gal. of crude carbolic acid liquid (30 per cent.), stir and cool a little. Lastly add 6 gal. more of carbolic acid liquid.

Sanitary Powders. —(*a*) Mix together 1 pint of turps and 2 qt. of soluble creosote. Sprinkle this over a mixture of 14 lb. ground alum and 70 lb. ground soda (carbonate). When dry pack into tins. (*b*) Mix together ¼ pint eucalyptus oil and 3 qt. best turps. Sprinkle these on a mixture of 245 lb. chloride of lime and 35 lb. ground naphthalene. Mix thoroughly. Pack in tins. This resembles sanitas powder.

Soluble Solid Pink (or other colour) Disinfectant.—Take 18 lb. naphthalene and melt by gentle heat in a large pan. Gradually add 4 lb. soft soap as the naphthalene becomes liquid. When the soap is nearly dissolved, stir well to make an emulsion, then let cool.

Add oil scarlet for pink colour stirring it well to get a uniform tint. Before it sets run it into frame moulds. It is then cut up to required size pieces. If a piece is put in water it very slowly dissolves and impregnates all the water passing it.

Detecting Sewer Gas.—The presence of sewage gas in an apartment may be detected in the following way: Saturate unglazed paper with a solution of 1 oz. pure lead acetate in ½ pint rain-water; let it partially dry, then expose in the room suspected of containing sewer gas. The presence of the latter in any considerable quantity soon blackens the test paper.

Sheep-Dip.—A good sheep-dip can be made by putting 1 gal. of sanitary carbolic fluid to 80 gal. of water.

Non-poisonous Sheep-Dip Paste.—(*a*) 2 parts creosote (containing 15 per cent. to 20 per cent. of carbolic acid), 1 part stearine or Yorkshire grease, 1 part caustic soda lyes, sp. gr. 1340, 5 per cent. to 10 per cent. parts black resin. Melt resin, and add grease and soda lyes, and then add creosote cold. (*b*) 1 part creosote, 1 part crude hard resin oil. Put resin oil in copper, and heat to about 220° F., and add as much caustic soda powder, 98 per cent. strength, as the oil will take up (the quantity depends upon the amount of acetic acid in the oil). If too much soda is added it will remain at the bottom. When resin oil has taken up soda, add creosote and let it set.

Cloudy Ammonia.—(*a*) 1 gal. aqua ammonia, 8 gal. soft water, 4 gal. good yellow soap, 8 oz. saltpetre. Cut the yellow soap in shavings and dissolve in soft water by heating, cool and add the 8 oz. of saltpetre and stir well until dissolved; strain, let settle, skim off all soap-suds, etc., then add the ammonia and bottle at once. (*b*) 1 gal. methylated spirit, 1 gal. soft water, 1 gal. strong liquid ammonia. Add the spirit and water together, shake well up and add ammonia, then well mix and bottle. (*c*) 80 oz. liquid ammonia, 80 oz. distilled water, 100 gr. soap, 5 dr. olive-oil. Cut the soap in shavings, and *boil it with the oil and water, cool* and add the ammonia and bottle. For use in laundries, baths, and general household purposes, add 1 tablespoonful to 1 gal. of water.

* * *

DISTILLING.

(*See also* EVAPORATING, ALCOHOL, PERFUMES, CHARCOAL, ETC.)

Small Apparatus for General Purposes.—(*a*) All ordinary distilling apparatus consists of 2 parts—one in which the heat is applied to the body to be distilled and vaporised (called the "still"), and the other into which the vapours that are formed enter in order to undergo the cooling that condenses them (termed the "condenser"). One of the simplest forms of distilling apparatus used in laboratories (Fig. 139) consists of a still

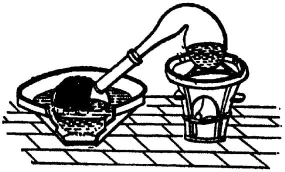

FIG. 139.

into which is introduced the liquid to be distilled, and which is placed upon a furnace. The neck of this fits into that of a sphere whose opening must be wide enough to allow the orifice of the still to reach the spherical part of the receiver. Finally, the sphere dips into a vessel full of cold water, and is cooled on its external surface by a wet cloth. The heated mixture begins to boil, and its vapours, escaping from the retort, cool and condense upon the cold sides of the spherical receiver. This latter serves at once as a condenser and a vessel for receiving the distilled product.

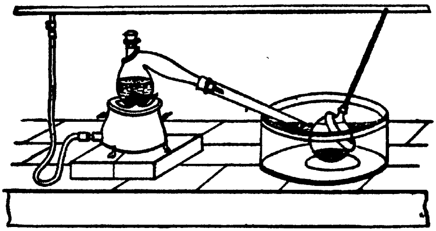

FIG. 140.

In the beginning, the empty receiver weighs less than the volume of water that it displaces, and tends to float, this may be remedied by using a sufficiently heavy ring of lead into which the neck of the receiver may be introduced, and which may rest upon the latter's bulge. Upon fixing a similar ring under the receiver, the latter will be prevented from turning laterally and even from getting broken. The water in the external vessel is renewed so as to keep it cold.

A simple arrangement of this kind is not adapted for materials that have a low boiling-point, since a large proportion of the vapour escapes, and makes its exit through the neck of a receiver, which is kept hot by the vapours coming from the still. The following which is just about as simple, is a much more perfect arrangement.

The narrow part of the still is fixed into the neck of a long, tubular receiver (Fig. 140) by means of a cork which it traverses. This annular cork exactly closes the space between the neck of the still and that of the receiver. On the other side, in the tubulure of the receiver, there is fixed by means of a cork, perforated and arranged like the preceding, a long and narrow glass tube.

When the still has been filled with the substance to be distilled, and placed upon a furnace covered with wire gauze, the receiver is immersed, as above stated, in cold water. The vapours that are formed become cooled in traversing the elongated neck of the receiver, and are thoroughly condensed in the immersed part, provided the ebullition is not too rapid. In this latter case, the narrow tube, which presents the only open orifice, becomes heated, and indicates to the operator that the fire must be moderated.

The inconvenience of every apparatus of this kind is that the vapours which enter the receiver are not compelled to impinge against the sides, and may go directly to the exit-tube, or, in other words, the refrigeration is not methodical. Moreover, the refrigerating surface continues to diminish in measure as the receiver fills. Finally, if the receiver breaks, the entire distilled product comes in contact with the water. Despite these disadvantages, the rapidity with which such apparatus may be arranged, causes them to be frequently employed.

The use of refrigerators permits of a more exact and methodical condensation of the vapours. These are arranged as follows: The 2 orifices are placed in contact by means of a rubber tube 2 to 4 cm. in length, into one end of which is introduced the neck of the retort *a* (Fig. 141), and into the other the tube of the refrigerator. The latter being held in an inclined position by means of a clamp, a current of water traversing it from top to bottom, and a bent tube being adapted to its lower extremity, the free extremity of the bent one is fixed into the flask that is to collect the product.

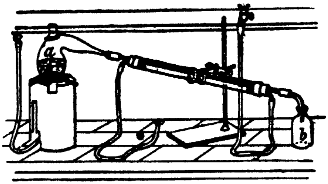

FIG. 141.

We may also suppress the central tube of the refrigerator in the flask *b*, kept inclined. To facilitate this arrangement, the neck of the retort is cut at a point where it has the same external diameter as the tube of the refrigerator, and is then edged with a flame. Again, if the difference between the diameters is considerable, we may, by means of a flame, draw out slightly the one of the two tubes that is the larger, and cut it at the proper point to obtain an equality in the diameters. Finally, we may solder to the extremity of the refrigerator a cylindrical tube, 2 or 3 cm. in diameter and 6 or 7 in length, into which is fitted the neck of the retort previously provided with a cork. This latter contains an aperture running in the direction of its axis, and the whole is arranged so as to form a tight joint.

When the substance distilled attacks cork and rubber, the neck of the retort is drawn out to a sufficient length to allow the tube that terminates it to enter the refrigerator to some depth. The rubber with which the two parts of the apparatus are connected is thus nearly out of the range of the vapours.

It is very evident that the still may be replaced, and advantageously too, in many cases, by any other spherical vessel with a narrow neck. In this case the receiver is closed (Fig. 142) by a cork or rubber stopper containing an aperture that is traversed, through slight friction, by a glass tube. This latter is so bent that the angle formed by its 2 branches shall correspond to the inclination that is given to the refrigerator. The external extremity of the tube is connected with the refrigerator by means of one of the arrangements described above for the neck of the retort. As for the internal extremity, it is well, especially if the tube is narrow, to bevel it off so as to facilitate the flow, drop by drop, of the condensed liquid, which accumulates therein, and which, without such a precaution, might be carried along by the vapour toward the refrigerator. Moreover, in the case of a liquid that

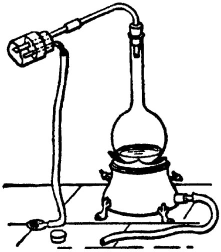

FIG. 142.

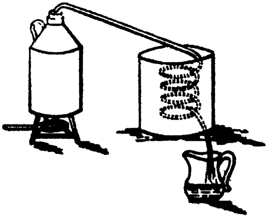

FIG. 143.

would attack the joints, the bent tube that fits into the neck of the receiver may be that of the refrigerator itself.

(*b*) One of the simplest forms of still consists (Fig. 143) of a tin can or bottle in which the water is boiled, and to this a tin tube is adapted by means of a cork, one end of this tin tube terminating in a coil passing through a tub or other vessel of cold water. A gas burner, as shown, is a convenient source of heat, and in order to ensure a complete condensation of the vapour, the water in the cooling tub must be changed now and again.

(*c*) Sometimes the vapour is condensed by being allowed to play against the inside of a conical cover which is adapted to a saucepan, and is kept cool by the external application of cold water; and in this case the still takes the form represented by Figs. 144, 145, and 146; the condensed water trickles down on the inside of the cone, and flows out at the spout.

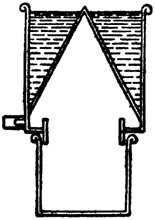

FIG 144

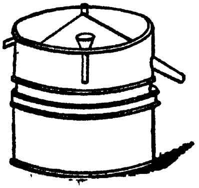

FIG. 145.

An extemporised arrangement of a similar character may be made by passing a tobacco pipe through the side of a tin saucepan as shown in Fig. 146, and inverting the lid of the saucepan; if the lid is now kept cool by frequent changes of water inside it, and the pipe is properly adjusted, so as to catch the drippings from the convex side of the lid, a considerable quantity of distilled water may be collected in an hour or so.

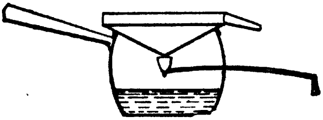

FIG. 146.

(*e*) The apparatus shown in Fig. 147 works admirably, and is very convenient. *a* is a common tin saucepan, with a small hole in the side, for a tobacco-pipe; *b* a "steamer," on top, with a bottom like an inverted cone, 1 in. of wire being soldered at the apex. A gas jet (Bunsen's, if possible) boils the water in the saucepan; the ascending steam is condensed on the lower surface of the steamer, runs down to the point of the wire, down the pipe into the bottle. A small jet of cold water keeps *b* cool.

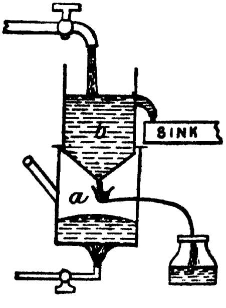

FIG. 147.

(*f*) Fig. 148 illustrates a little earthenware distilling apparatus in use among the Japanese. It consists of 4 pieces; a boiler *a*, on to which fits a short cylinder with a perforated bottom *b*, and over this a condenser *c*, with a cover *d*. The cover being removed, a stream of cold water can be kept running into the condenser by means of a bamboo, and the overflow carried off by the spout at its base. Round the base of the inner side of the middle cylinder runs a ledge which forms a channel opening into an exit spout. The materials for distillation are put into the boiler, and the whole is placed on the ordinary *hibatchi*, or domestic fire-box. The vapour passes through the perforated bottom of the cylinder, collects in drops on the dome-shaped inner surface of the condenser, runs down into the channel before described, and is collected at its exit from the spout. This little contrivance is known by the Japanese under the name of *lambik* or *ranbiki*, which is doubtless some corruption, through the Dutch, of the word alembic. In the country districts peppermint is largely used as a corrective for water rendered muddy and otherwise unsuitable for drinking by rains, as well as for other domestic purposes, and this apparatus is one of the means employed for its distillation.

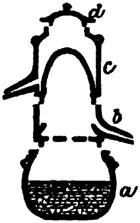

FIG. 148.

(*g*) Lord Rayleigh has described a form of still which may, perhaps, have important industrial applications. From theoretical considerations, and from certain experiments, he was led to the view that it would be advantageous to feed in the liquid to be distilled, not, as usual, at a point where the temperature is highest, but elsewhere, thus enabling the more volatile component of the crude liquors to be drawn off continuously at one end, whilst the less volatile is withdrawn at the other. His apparatus, which has given good results even with alcohol, consists of a couple of coils of copper tubing, 12 millimetres in diameter. Each of these coils was placed in an iron pail, the two being arranged on different levels. The longer coil was placed in the lower pail, where it was surrounded by boiling water. The other coil was surrounded with water kept at a temperature of 77° C. The two spirals were connected by a glass tube having a branch through which the liquid to be distilled was fed in. This glass connecting tube was inclined at the same angle with the horizon as the coils of the tubing, so that the gradient of the whole system of tubing was uniform from end to end. The open end of the top coil was connected to an ordinary condenser, in which the spirit distilled was collected, whilst the watery constituent was collected at the lower end of the tube system. The still, it will be seen, works continuously. The liquor to be distilled being fed in between the two coils, a double stream is established in the system, a stream of vapour ascending towards the upper coil, and a stream of liquid descending towards the lower one. In these conditions very little spirit reaches the end of the lower coil, and very little separable water the end of the upper coil. It is well known that by distillation pure and simple it is impossible to free spirit from the last 10 per cent. of water, and in the experiments in question the concentration attained ranged from 89 to 90·3 per cent. of spirit, and the water collected at the lower end never contained more than ½ per cent. of alcohol.

(*h*) A homely still can be made with

one of those large stone bottles used for beer, say a 3-gal. one, with a vent at the bottom for a wooden cock. That would be the condenser. For the still or vaporiser get one of the steaming kettles used for bronchitis. To the tube of that fasten by a union a length of pipe that will reach from where you generate the steam to the bottle, which latter place outside upon your window sill. If a north front, so much the better. Take the pipe ⅜ down into the bottle. The surface of the large bottle exposed will condense the steam, and the liquid can be drawn off at bottom as wanted. Use tin pipe. Have the nose of bottle open.

(*i*) The arrangement shown in Fig. 149, is one that may readily be adapted to, and is specially suited for, the old fashioned stills which are in frequent use among pharmacists for the purpose of distilling water. The idea is extremely simple, but thoroughly efficient in actual practice. The still is of thin copper, 2 gal. capacity, and the condenser is the usual worm surrounded with cold water. The overflow of warm water from the condenser is not run into the waste pipe as in the ordinary course, but carried by means of a bent tube A B C, to the supply pipe of the still. The bend at B acts as a trap, which prevents the escape of steam. The advantages of this arrangement are obvious. It is perfectly simple, and can be adapted at no expense. It permits of a continuous supply of hot water to the still, so that the contents of the latter may always be kept boiling rapidly, and as a consequence it condenses the maximum amount of water with the minimum of loss of heat. If the supply of water at D be carefully regulated, it will be found that a continuous current will be passing into the still at a temperature of about 180° F., or, if practice suggest the desirability of running in the water at intervals, this can be easily arranged. It is necessary that the level at A should be two inches or thereabout higher than the level of the bend at C, otherwise there may not be sufficient head to force a free current of water against the pressure of steam. It will also be found that the still should only contain water to the extent of about ¼ of its capacity when distillation is commenced, as the water in the condenser becomes heated much more rapidly than the same volume is vaporised. By this expedient a still of 2 gal. capacity will yield about 6 gal. per day, a much greater quantity than could ever be obtained under the old system, which required the still to be recharged with cold water every time 1¼ gal. had been taken off. The objection to all such continuous or automatic arrangements is, of course, that the condensed water contains all the free ammonia that may have existed in the water originally, but it is only in cases where the water is exceptionally impure that this disadvantage will become really serious. (T. Maben.)

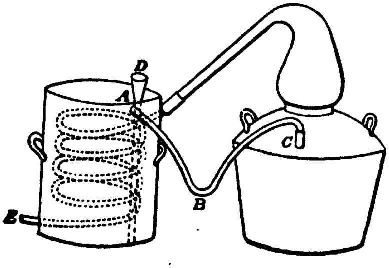

FIG. 149.

Solar Distillation.—An apparatus employed in Las Salinas in Chile, for the distillation of water by the action of the sun's rays, was designed by Charles Wilson in 1872. The site selected for the establishment was a smooth plain, with an inclination of about 1 in 100 towards the old watercourse, in which are wells for salt water. The apparatus consists essentially of a number of long shallow troughs, filled with water, and covered by a sloping glass roof. The water is evaporated by the sun's rays passing through the glass ; the vapour is condensed on the under surface of the glass, runs down to grooves cut in the wooden frame, and thence, by a system of pipes, to the fresh-water tank. There are in the establishment at Salinas 64 frames, each 200 ft. long by 4 ft. broad, giving a total area of 51,200 sq. ft. of glass. Each frame is composed of 2 principal parts, the water-trough and the roof. The trough is constructed of 3 longitudinal sleepers, 4 in. by 4 in., on which the planking (1½ in. thick) is laid. The sides are composed of timbers, bolted to the sleepers at every 6 ft., the whole being carefully jointed inside with putty, to render it perfectly water-tight, and having an inclination of about 1 in. in the total length in the direction of the wash-out plug. The roof is constructed in 10 lengths of 20 ft. each. The sides are of pine, with the upper edge properly cut to receive the glass, and a groove for conveying the condensed water to the outlet-pipes, which are placed at the lower end of each section, the grooves having an inclination of 2 in. in 20 ft., in addition to the inclination of the trough. The end frames of the 20-ft. sections of the roof, excepting those which coincide with the ends of the troughs, are carried down to a little below the water-level, to prevent the escape of vapour in the joint, there being, in fact no outlet for the vapour, excepting by the small leaden pipes which carry off the condensed water. The ridge is supported by the end frames and intermediate uprights resting on the bottom of the trough. The sashbars are movable, so as to suit varying widths of glass.

The salt water is admitted by a 1-in. brass cock at the higher end of the trough, and a wooden plug for washing out is provided at the lower end. There is also, at the lower end, an overflow pipe, the point of which is turned down below the water, to prevent the escape of vapour. The salt water is pumped from the wells by a windmill into a tank at the upper end of the grounds, sufficiently large to contain about 4 days' supply. The water from the tank is distributed to the various troughs by a 2-in. wrought-iron pipe, with the necessary connections. The fresh water is collected from the small leaden pipes into a 1½-in. wrought-iron pipe running between the troughs, and connecting with a 2-in. main pipe at the end, which leads to the storage tanks. To increase the evaporation, the bottoms of the troughs are blackened with logwood and alum, and are washed out every second day, by running salt water through them.

When first set to work, the establishment produced daily, in summer, upwards of 5000 gal. of fresh water, about equal to 1 lb. of water per sq. ft. of glass ; but after the opening of the railway, the owners grew careless, and allowed the troughs to get out of repair, so that, through leakages and insufficient cleansing, the production gradually fell off to about ⅓ of the above. When not properly attended to, crystals of soda and lime sulphate (Glauberite) form in the troughs, directly diminishing the production, and indirectly leading to loss by leakage when the crystallisation takes place between the planks, and so forcing open the joints. When properly maintained, the cost of water, including interest on capital, renewals of glass, etc., amounted to less than 1 cent per gal. The principal item of expense is the renewal of glass broken by whirlwinds, which are very frequent in the locality. The staff consists of a clerk, who keeps the accounts, sells the water, and manages the business generally ; and of a glazier, and 2 labourers for cleaning and repairs, and at intervals a carpenter to restore the woodwork.

The temperature of the water in the troughs at noon (when the thermometer stands at 80° F. in the shade), is 140° to 150° F. The distillation usually begins at about 10 A.M. and ends at about 10 P.M.

Such an apparatus as this necessarily requires a good deal of weight owing to the cracking and decay of the woodwork, but a more permanent form could be readily erected with concrete or reinforced concrete construction.

Tinctures, Extracts, etc.—(*a*) A very convenient and complete still is shown in Fig. 150. The body holds over 3 gal.; the condenser has 7 straight tubes surrounded with the cold water introduced by a rubber tube from a hydrant or bucket of water placed higher than the still, and carried off as it becomes warmed by another tube as indicated by the arrows. By the siphon arrangement shown in the cut, it is possible to feed the still from a reservoir whilst distillation is in progress, thus using a 3-gal. still where a much larger one would have been necessary. The still may be set into a kettle partly filled with water, and thus used as a water-bath, or a shallow dish, with flat rim, which accompanies the still, may be placed between the two brass ring bands and clamped securely.

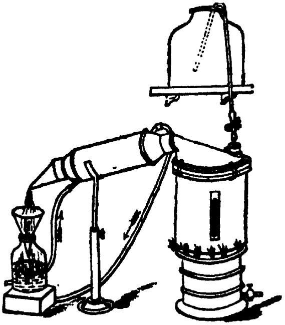

FIG. 150.

(*b*) Stevens arranged the apparatus shown in Fig. 151 for continuous distillation. As soon as the water passes out of the boiler *a*, the float *b* lowers, letting a fresh supply of water from the condenser *c* through *d*, thereby keeping the water in the boiler at a constant level. This avoids the necessity of adding a large quantity of cold water at once, the effect of which would be to reduce the temperature of the water below the boiling-point.

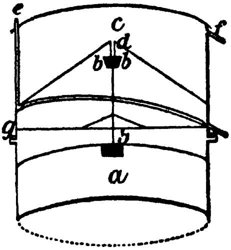

FIG. 151.

Cold water is supplied to the condenser through *e*, and as it becomes heated and rises to the top, it is carried off through *f*. The boiler and condenser are joined at *g*.

By leaving out the float and closing the inlet *d* with a cork, it can be used for distilling other liquids.

The apparatus is not patented, and should any pharmacist desire to make one for his own use, he can do so.

(*c*) For the purpose of distilling a series of samples at one time, Dr. B. Landmann devised an apparatus which appears to be very compact, and may be fastened against the wall, so as not to interfere with other available space in the laboratory. It consists (Fig. 152) of a common, tinned-iron cooler A, 21¾ in. long, 12 in. high, and 2 in. deep, with a series of openings *a*. for passing through the condensing tubes, and an inlet and outlet for water and *h*. The cooler stands upon 2 iron supports *b*, about 9¾ in. long, to the front ends of which is attached the gas-pipe *f*, which is provided with 6 stop-cocks and a lateral burner. The 2 iron supports are firmly held in place by the two parallel rods *c*, and the iron framework *d*, which is 1¾ in. distant from the cooler, has a height of 8 in., and a width of 2¾ in. The receivers are placed upon a board which is laid across the supports *c*. As it is necessary that quite a number of connecting tubes should be on hand, it is advisable to bend them all after a pattern or drawing made upon a board. Should the corks through which the cooling tubes *a* pass not be sufficiently tight, it is only necessary to pour melted paraffin through the orifice *g*, until it has coated the bottom of the apparatus.

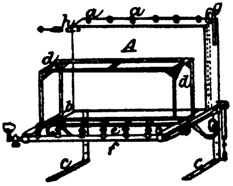

FIG 152.

(*d*) The distilling apparatus represented in Fig. 153 is intended primarily for the use of pharmaceutical chemists or druggists, but it possesses features which will recommend it to many who have need of a trustworthy and quick-acting still. The wide delivery tube is a useful feature, allowing as it does for the accumulation of vapour, and permitting the introduction of the hand. The body of the still is of wrought iron or copper, with a lid fitting on ground edges, and held together by screw-clamps, as seen in the engraving. A gauge is fitted to show the quantity of liquid in the still. The condenser consists of a number of glass tubes, which, if they are 1 in. diameter and 24 in. long, expose a surface of 264 in., while that of the surrounding cylinder is only 188½ in. The ends of the condenser tubes are drawn together and tapered, as shown in cut, to permit, if desired, the collection of the distillate in a narrow-mouthed bottle. The advantage gained by this apparatus, aside from the general one of convenience, is thus seen to be in the notable increase of condensing surface it exposes, which to that extent increases the effectiveness of the device—i. e. its rapidity of action. Compared with a Liebig condenser of similar dimensions, this apparatus exposes probably 3 times as much condensing surface. The idea of a tubular condenser, employed in the manner set forth, is, in the opinion of the 'American Journal of Pharmacy,' an excellent one, that may find useful imitation in the chemical laboratory and elsewhere. The device illustrated and described was invented by Joseph P. Remington, whose recommendation of its merits is based upon a continuous use of it for 3 years.

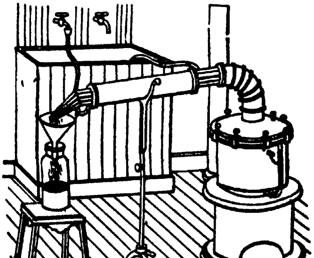

FIG. 153.

(*e*) In chemical or pharmaceutical operations, it often becomes necessary, after having used an upright condenser for the purpose of continuous extraction, to reverse the whole condenser, in order to recover the volatile menstruum. This also necessitates, in most cases, a change of the current of water for cooling the apparatus. All this may be avoided by constructing the condensing tube in the manner shown in Fig. 154. From a bulbous expansion blown in the tube at its lower end, a tube *c* arises, provided with a faucet *d*, and subsequently turned at a right angle downwards. At about the centre between the faucet and the angle, the glass tube passes through a support connected with the condenser, whereby it is in a great measure protected from being broken off. The use of this modified condenser is almost self-evident. If it is used for continuous extraction, so that the condensed liquid constantly flows back into the flask connected with *a*, the faucet at *d* is closed. The condensed liquid will then at first fill the tube *c* until it flows over into the tube *a*. Finally, when the operation is to be finished, a receiver is placed under *e*, and the faucet is opened, when all the condensed liquid may be collected without disturbing the connections of the condenser. It is advisable before opening the faucet *d* to dip the end of the tube *e* into a flask containing a portion of the liquid which is to be distilled over. The depth to which the tube may be dipped should be less than the length of the column of liquid contained between *c* and *d*. (Simand.)

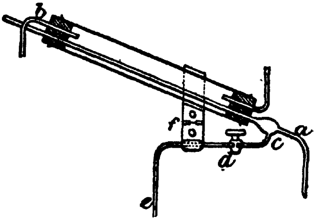

FIG. 154.

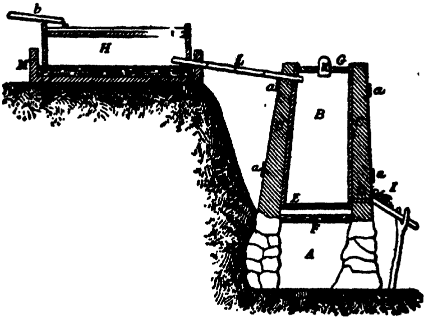

FIG. 155.

(*h*) *Camphor*.—The wet distillation of camphor is a process for extracting organic products. The most general arrangement of the still and condenser adopted in the Tosa district of Japan is shown in Fig. 155. On a small circular stone wall A, serving to form a fire-place, lies an iron plate F, 2½ in. thick. This is covered by a numerously perforated lid, luted tightly with clay, which at the same time forms the bottom E of the vessel B, which is 3 ft. 4 in. high, and 18 in. wide at the top. Near the bottom is a square opening D, which may be closed by a board. The whole is clothed with a thick coating of clay C, held fast by a binding of bamboo hoops *a*. The upper opening is closed by a clay-luted cover G, having a hole in the centre, furnished with a cork K. Just under this cover, a hollow bamboo stem leaves the still and passes to the condenser *h*. This consists of a 4-sided box open beneath, divided into 5 inter-communicating compartments by means of 4 partitions, and turned with its open side into a vessel M containing water. This condenser is kept constantly cool by a stream of water, led over the top by means of the pipe *b*. The distillation is conducted in the following way. After removing the cover G, the vessel B is filled with the chips of camphor wood, the cover replaced and well luted with clay; then through the opening K, a certain quantity of water is run in, which, after saturating the chips, will collect in the pan F. Gentle firing is now commenced, and is continued for 12 hours, so as to keep the water in F at a steady boil. The ascending steam, finding its way among the chips, carries all the camphor with it, and on condensation in the cooler H, the camphor is deposited, and removed at suitable intervals.

Such a simple and efficient apparatus ought to afford a valuable hint to many a colonist who wishes to utilise natural products of a similar character.

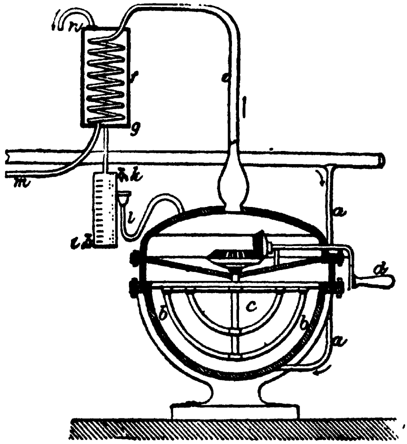

FIG. 156.

(*i*) *Flowers, Plants, or Seeds.*—To obtain the essential oils, from flowers, plants, or seeds, the oleiferous material is placed in an iron, copper, or glass still, of 1–1000 gal. capacity, and is covered with water, superposed is a dome-shaped lid, terminating in a coil of pipe, placed in a vessel of cold water, and protruding therefrom with a tap at the end. On boiling the contents of the still, the essential oil passes over with the steam, and is condensed with it in the receiver; the oil and water separate on standing. A great improvement, introduced by Drew, Heywood, and Barron, is the use of a steam-jacketed still, as shown in Fig. 156. Steam is supplied from a boiler by the pipe *a* into the jacket *b*; within the head of the still, is fixed a "rouser" *c*, a double-branched stirrer curved to the form of the pan, and having a chain attached and made to drag over the bottom, the whole being set in motion by means of the handle *d*. The still is charged, and nearly filled with water; the head is then bolted on, steam is admitted into the jacket, the contents are well stirred, and soon the oil and steam are carried up the pipe *c*, condensed in the refrigerator *f*, and let out at *g* into the receiver *h*. Here the oil and water separate and escape by different taps. In the illustration, it is supposed that the oil obtained is heavier than water; it will then sink, and be drawn out by the lower tap *i*, and, as soon as the water reaches the level of the upper tap *k*, it will flow into the siphon-funnel *l*, and thence into the still. Thus the same water is repeatedly used in the still. The pipe *m* conveys cold water into the refrigerator *f*; the water escapes as it becomes hot by the pipe *n*. When the oil distilled is lighter than water, the taps *i k* exchange duties. Before commencing operations, the siphon *l* is filled with water to prevent the escape of vapour.

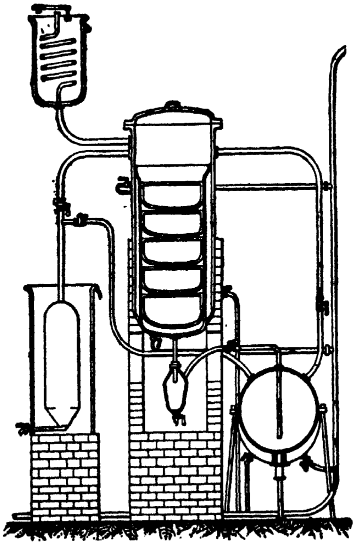

FIG 157.

(*j*) An apparatus constructed by Rigaud and Dussart is arranged so that dry steam enters directly among the matters to be distilled, and the temperature is always maintained at a high point. This is shown in Fig. 157. It is claimed to yield a larger and superior product, and to prevent all chance of creating an empyreumatic odour, such as sometimes happens with other forms.

(*k*) Distillation as a means of obtaining essential oils is worthy of every consideration. Generally it should be effected by steam; but there are cases (bitter almonds, etc.) where contact with water is necessary for the production of the oil, while in others, open fire and steam are equally applicable, though the latter is superior. The water employed must be perfectly pure and neutral, though in some cases (sassafras, cloves, cinnamon, etc.) common salt is added to raise the boiling-point. The receiver is always some form (there are many) of "Florentine receiver." In some instances (anise, etc.) where the distillation-products are solidifiable at a low temperature, the condenser-worm needs to be warmed instead of cooled.

Mercury is so largely used both in the laboratory and for industrial purposes, such as ore reduction, electric engineering, and so on, that a quick and efficient means of purifying it is a valuable acquisition.

The usual processes for purifying mercury are either chemical, such as treatment with dilute sulphuric acid, etc., or mechanical, such as shaking and filtering through wash-leather, or distillation, either *in vacuo* or under the ordinary atmospheric pressure. Of all these methods the best is distillation *in vacuo*.

Prior to distillation it is well to filter the mercury through a cone of writing paper with a very small orifice at the apex, and to remove the lead or zinc present by chemical means; for the rate of distillation is lowered by these impurities. The presence of 0·0001 part of lead is said by Gmelin Krant to reduce the quantity of mercury distilled in a given time from 67 to 5. Gold, iridium, copper, tin, nickel, cadmium, and arsenic do not influence the rate of distillation.

The distillation of mercury at ordinary pressure is an inconvenient process. The first apparatus for distilling *in vacuo* was probably devised by Weinhold, and others have been designed since by Weber, Shaw, Wright, and others. The arrangement of Clark, however, differs from all these in the important respect of dispensing with an auxiliary Sprengel air pump, and in, so to speak, acting as its own air pump. This is effected by supplying the mercury to be distilled from a movable reservoir in the form of a constant level regulator. On raising this reservoir, Fig. 158, the mercury is supplied to the distiller.

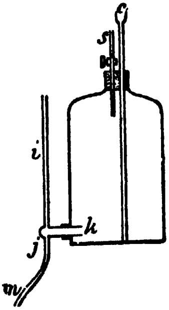

FIG 158.

The distiller is shown in section in Fig. 159, and consists of a lead glass tube *a b* 36 in. long and about ⅜ in. internal diameter. About 2 in. from its closed upper end is blown a bulb, about 2 in. diameter. The lower end passes through an air-tight cork of rubber, closing the top of the cistern *d c*, and ends at *b*, a little below the tube *f*. The cistern *d c* is made of glass tube 1 in. diameter and 12 in. long and has two short pieces of "quill" tubing *e f* sealed into it. The lower end is also closed by a cork, through which passes a piece of Sprengel tube *i* 36 in. long, and having a piece of quill tubing *h* about 24 in. long sealed into the upper

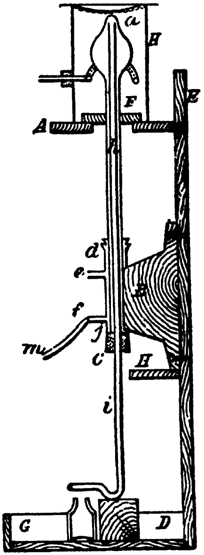

FIG. 159.

end. The top of this tube is nearly in contact with a. The internal diameter of the Sprengel tube should not much exceed 1 mm., and the bend of the lower end is best when not much more than 1 in. radius.

The base of the stand is a wooden tray GD, from which rises a board DE, carrying a shelf AE, perforated in the centre with a hole allowing the glass bulb to pass through it. A large cork F is bored with a hole of rather less diameter than the tube $a\,b$, and the cork is cut in halves. The tube is held in position by twisting a piece of copper wire round the halves of the cork. The cistern is secured by string passing through holes in the projecting piece of wood B. A block of wood serves to support the end of the tube i, and a tin cylinder notched round the top, and covered with a flat tin plate, keeps the bulb surrounded with hot air, while a mica window at the side allows the height of the mercury in the bulb to be easily seen. The pipe of the brass ring burner passes through a hole in the tin gas plate, and the ring, slightly larger than the bulb, is perforated on its inside with many holes.

The constant level reservoir is a large glass bottle provided with a tubulure at the side. Similar bottles are now made for the mercury pumps of electric incandescent lamp manufacturers. Into the tubulure passes a glass tube k about 3 in. long and ½ in. diameter. Its outer end is closed, and into the upper and under sides are sealed two pieces of quill tubing $i\ j$. The top of the upper end is open, but the lower j is connected with the cistern of the distiller by a narrow piece of rubber tubing m, about 3½ ft. long, inclosed in a canvas tube. The "thistle" funnel c and small glass stop-cock s are also fitted air-tight into the bottle by a rubber tube. The reservoir is placed on an adjustable table stand on the shelf.

To set the distiller in action, the stop-cock s of the reservoir is opened, and some mercury is poured through the thistle funnel c into the reservoir, while, with a short piece of rubber tubing and glass rod, the tube c is closed securely (Fig. 159) at the top by the cistern. Then the reservoir is raised. The mercury gradually rises in the cistern, and by compressing the air in the upper part is forced up the tube $a\,b$, and then filling the bulb "sprengels" down the tube $h\ i$. The reservoir may then be lowered to its stand on H, and the rubber stopper removed from the tube c. The reservoir is set in action by attaching a piece of rubber tube to the stop-cock s, and sucking out air until, passing down the tube i it bubbles up through the mercury in the reservoir. Then the stop-cock is closed, and the reservoir is adjusted at such a height in the stand that the mercury is nearly at the top of the bulb in the distiller. Thus set in action, the level of the mercury in the cistern $c\ d$ will be kept constant until almost all the mercury has been distilled.

To start the distillation the tin plate which covers the cylinder is removed, and the gas is lighted. A few minutes later sufficient mercury will have distilled over to displace the impure mercury originally present in the narrow Sprengel tube i.

The reservoir is replenished with mercury without interrupting the distillation, by placing a screw pinch-cock on the rubber tube leading to the cistern of the distiller, opening the cock s, and pouring the mercury into the reservoir through the funnel c. Then a few bubbles of air are sucked out of the reservoir as already described, the stop-cock is closed, and the screw clamp is released from the rubber tube. The level of the mercury in the distiller remains as before.

Such an apparatus as that illustrated will distil about 2 lb. of mercury per hour with an expenditure of very little gas. Zinc, cadmium, magnesium, and other metals may also be distilled by the same plan.

Spirit. (*Also see* ALCOHOL).—(*a*) The distillation of spirit is performed for the purpose of separating the alcohol more or less from the water. The boiling-point of water at the ordinary standard pressures of the atmosphere, equal to 30 in. of mercury, is 212° F. (100° C.), that of alcohol 173·1° F. (78·5° C.). At the sea level, the pressure of the atmosphere may frequently vary between 28·5 and 30·5 in.; the boiling-points of water corresponding to these temperatures are 210° F. and 213° F. Indeed, changes in the weather may cause the boiling-point of water to vary as much as 5° F. in our climate. These alterations in pressure would cause corresponding changes in the boiling-point of alcohol. If we gradually raise the temperature of alcoholic fluids to a point when vapours are freely formed, it is observed that though there is a continuous absorption of heat, yet the liquid does not increase in temperature. The heat which is absorbed during the first period is doing work of a different character from that employed subsequently. There are two phases in the process, and two different kinds of work performed by the heat employed in boiling even a kettle of water.

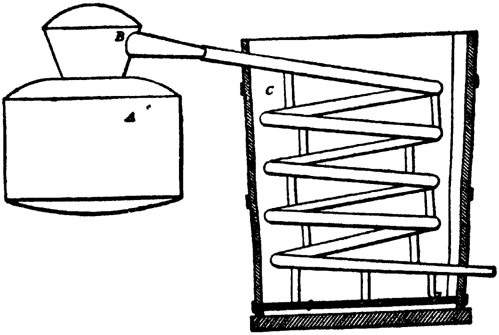

FIG. 160.

The first phase is indicated by a rise of temperature from 60° F. to 212° F.; the second phase by a change of state, from that of a liquid at 212° F. to a vapour at the same temperature. The quantities of heat required by different liquids in these changes varies greatly, but the variation is greatest when they pass through the second phase. Thus 1 lb. of steam at 212° F. if converted into water at 212° F. will give up heat sufficient to raise 996 lb. of water from 60° to 61° F. The heat rendered up by 1 lb. of alcohol vapour at 173° F. during condensation to liquid at 173° F. will heat 374·9 lb. of water from 60° to 61° F. These figures are sufficient to show that a small quantity of steam will boil a large quantity of alcohol. Stills of improved construction depend upon this principle.

When a mixture of alcohol and water is distilled, the liquid will not boil constantly at 173° F. until all the alcohol has passed over, but will rise in temperature gradually throughout the distillation until 212° F. has been reached. The distillate, if separated into fractions boiling between fixed points, consists of a series of mixtures of alcohol and water in definite proportions. The mixtures richest in alcohol come over first, that is to say, at the lowest temperature.

The latent heat of the vapour of a liquid with a high boiling-point, can be made to boil a liquid with a lower boiling-point; for instance steam at 212° F. can boil alcohol at 173° F., and alcohol at 173° F. in turn can boil ether at 94·8° F. With a simple still, strong alcohol can be obtained from wash by repeated distillation only. Woulffe realised the fact that this wasteful and tedious process could be dispensed with, by connecting together a number of rectifying chambers in such a manner that the vapour driven off from the chamber nearest the fire should be condensed in the second, and by the heat given out by its condensation cause the more volatile portions of the liquid of the second to distil into the third chamber, and those of the third into the fourth, and so on, until a sufficient degree of concentration is attained.

(*b*) The simplest form of spirit still is shown in Fig. 160, and consists of 2 essential parts, the still or boiler A, which is made of tinned copper, and enters the furnace, and the cooler or worm C, a pipe of block-tin or tinned copper, bent into a spiral and connected with the top of the still. The liquid is boiled in the still, and the vapours passing over are condensed in the pipe, which is placed in a tub or vessel containing cold water. This simple apparatus is not much employed in distilling, as it is impossible to get sufficiently pure products from it on a commercial scale. In an arrangement of this kind, the vapours of alcohol and water are condensed together. But if, instead of filling the cooler with cold water, it be kept at a temperature of 176° F. (80° C.), the greater part of the water will be condensed; but the alcohol, which boils at 172½° F. (78° C.), passes through the coil uncondensed. If, therefore, the water be condensed and collected separately in this manner, and the alcoholic vapours be conducted into another cooler, kept at a temperature below 172½° F. (78° C.), the alcohol will be obtained in a much higher state of concentration than it would be by a process of simple distillation. Supposing, again, that vapours containing but a small quantity of alcohol are brought into contact with an alcoholic liquid of lower temperature than the vapours themselves, and in very small quantity, the vapour of water will be partly condensed, so that the remainder will be richer in alcohol than it was previously. But the water, in condensing, converts into vapour a portion of the spirit contained in the liquid interposed, so that the uncondensed vapours passing away are still further enriched by this means. Here, then, are the results obtained: the alcoholic vapours are strengthened, firstly, by the removal of a portion of the water wherewith they were mixed; and then by the admixture with them of the vaporised spirit placed in the condenser. By the employment of some such method as this, a very satisfactory yield of spirit may be obtained, both with regard to quality, as it is extremely concentrated, and to the cost of production, since the simple condensation of the water is made use of to convert the spirit into vapour without the necessity of having recourse to fuel. The construction of every variety of distilling apparatus now in use is based upon the above principles.

* * *

DOOR HANGING.

IT is peculiar to note that, practically but little improvement has been made in the hanging of room or outer doors, except that which has been effected by the hinge maker, who certainly has introduced a good deal of ingenuity into his work, particularly of late years, but which has not done away with the unsightly gaping crack that always appears down the hinged edge of a door when it is opened to even a trifling extent, this crevice permitting anyone outside to view the greater part of the apartment within almost at a glance, and also allowing a keen draught to pass through, which although not objectionable in summer, is intolerable in winter, and it is in winter that the draught is stronger, by reason of the fire being alight in the room. Yet both of these objections can be obviated in a most simple and inexpensive manner—so cheaply, in fact, that every door in the house might be so fitted, from the kitchen to the attic.

The want of such a remedy has been quite recognised for many years, and probably from the time that doors were first introduced, and resource has been had to strips of ornamental leather, draught tubing, etc., and with valuable doors by making the edge of the inner stile semi-circular, this rounded edge fitting and working in a circular recess in the door frame, or post; but this latter means necessitates very skilful workmanship, and, as a butt hinge cannot be used, the door has to be pivoted top and bottom at proportionately greater expense. There are also other ways of fashioning the stile edge and door frame to the same end; but none have general favour for common doors on account of the greater cost.

The method about to be described may have occurred to the minds of many, and may probably be found in use, its simplicity being so marked that it cannot have escaped notice; but that it is not generally known is quite certain, and this fact makes its description desirable.

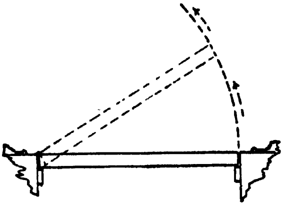

FIG. 161.

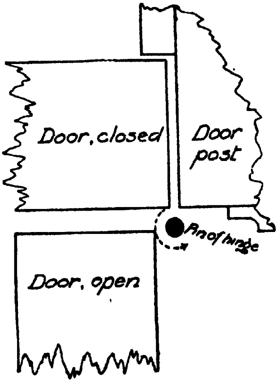

FIG. 162.

It is, of course, within everyone's knowledge that a hinged door when in the act of opening describes a segment of a circle, as indicated by the arrows in Fig. 161, and this circular movement not only takes place at the outer edge but at all points along the width of the door, even at the hinged edge (where, of course, the circle described is much smaller), as indicated by the arrow point and dotted line in Fig. 162. It is this circular movement that throws open the joint that must exist between the door-stile and the door-post, this joint being perhaps perfectly close while the door is shut.

Now, if we take a slip of wood with a circular bead at its edge, as Fig. 163 (section about full size), or the bead could be provided at the extreme edge of a piece of moulding, as Fig. 164 (about half natural size), and place it so that the bead covers the joint between the stile and the frame, the remedy is complete, as the hinged edge of the door will be found to work *around* this bead without the least difficulty, not in any way coming in contact and wedging one against the other, as may be supposed, but working freely, and in a manner that will please the eye of a skilled workman, and the object aimed at will be found to be fully attained, as this bead will obstruct the view through the fissure, and make it very nearly draught-tight.

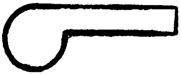

FIG. 163.

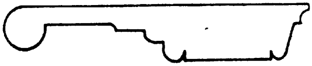

FIG. 164.

In applying this bead for the purpose explained, it is necessary to observe just three things: Firstly, the bead must be round, as shown in Fig. 163; secondly, it must be placed so that the centre of the bead comes over the joint (when the door is closed), so that a straight line continued from the joint would intersect the bead as near as possible exactly across the centre; thirdly, the size of the bead is governed by the projection of the knuckle of the butt, so that a 3-in. butt which is commonly fixed with the knuckle projecting ⅜-in. *to the centre of the pin*, would require a ¾-in. bead—i.e. whatever the projection from the stile to the centre of the hinge pin is, then the bead requires to be double this size; but this is only a theoretical measurement, as the edge of the stile never comes perfectly tight against the door-frame, and a little larger bead will generally be found desirable, but this can be ascertained by offering up a piece of bead, or even a pencil, but it is not at all necessary that a very exact fit be obtained, as moderate accuracy will be found quite sufficient.

Fig. 165 shows the position of the bead over the joint, the dotted line showing how the centre of the bead should be made to come opposite the joint; and Fig. 166 shows the butt and the outline of the bead (which comes above and below it, as no bead can be placed just where the butt projects); and by referring to Fig. 162 it will be seen how the stile travels *around* the bead as the door is opened, the bead all the while obstructing the view and the passage of draught through the joint.

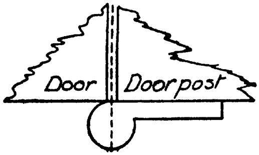

FIG. 165.

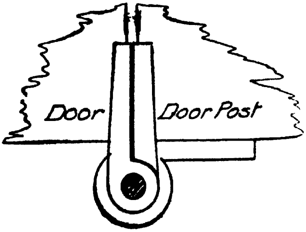

FIG. 166.

It will be noticed that in Fig. 166 a large-sized bead is shown, this being necessary by the greater projection of the butt knuckle. This suggestion will be found easy of application, and there is no reason why it should not be adopted with all doors, as it is generally recognised that although an open crack always shows itself down the hinged edge of a door when it is open, it would be much better were the crack absent. ('Building News.')

* * *

DRAIN PIPES.

Jointing.—(*a*) In Fig. 167 we have, in section, the ordinary cement joint as it is applied to pipes having ordinary socket and spigot ends. The cement material is made up of 1 part Portland cement and 1 part of sharp washed sand. This, when well trowelled, makes a joint that can be relied upon, and it will be seen that the following examples of patent joints are mostly backed up with cement, which says much for this latter material.

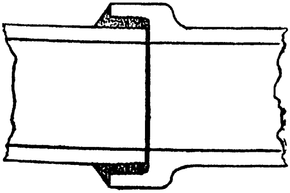

FIG 167.

(*b*) Fig. 168 is Doulton's "self-adjusting" joint, made expressly to admit of a slight strain throwing the pipes out of alignment; in fact, it is stated to be possible to lay a drain to a curve with this joint, and yet be as sound as if laid straight. The joint is formed of two bands of composition, cast one on the spigot and one in the socket of the pipe, as shown. The composition on the spigot has a slightly rounded surface, while the lining of the socket is quite straight (like the interior of a cylinder or tube). In consequence of this arrangement, if a pipe is laid or pushed a little out of straight the rounded surface works in the socket much like a ball and socket, and even in event of a pipe being drawn out a trifle it does not necessarily break the joint. The joints are, of course, rapidly made, and it is claimed that they are particularly useful in water-logged ground (with water in the trench). In those cases, however, where no advantage is likely to be experienced by the flexibility of this joint, then the firm make what is called the "Composite" joint. This resembles the last, but the socket is made deeper to admit of the composition joint being backed up with cement. The composition prevents the cement working into the pipe.

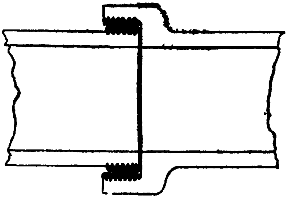

FIG. 168.

(*c*) Fig. 169 is Stanford's joint, much resembling the last described. This is an asphalt joint, but without being adjustable in any way. It is backed up with cement as shown.

Fig. 170 is another composition joint.

This has composition for the actual joint, but it is backed up with cement. In this case the composition on the spigot end is made taper so as to ensure a fit, for with other joints of this kind the least inaccuracy in size amounts to little better than a failure by leaving the joint unsound at that point. The cement backing in this joint is made specially secure by the circular channel shown in the socket.

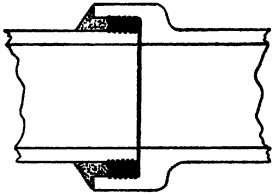

FIG. 169.

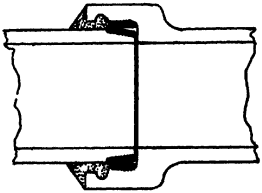

FIG. 170.

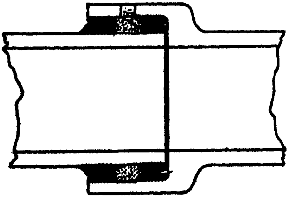

FIG. 171.

(*d*) Fig. 171 is Hassell's patent double-jointed pipe. It is claimed chiefly for this that the joint, having a double bearing, considerably reduces the likelihood of fracture or settlement. The two bands of bituminous materials are about 1½ in. apart, and between these rings is a space which is filled with liquid cement through a hole at top. The cement travels down, and fills the space around the pipe, making a good junction between the composition joints, but some detractors of this joint say that in this latter detail is the joint's weakness. It is urged that unless the workman be very careful he may not have his cement liquid thin or clear enough to run into the space in a regular manner to ensure a good joint; on the other hand, if the liquid is too thin it may pass through the composition joint if it does not fit perfectly sound, and so flow into the pipe.

(*e*) Fig. 172 is Hassell's single-jointed pipe, which is very similar to the double, only that the outer rim of composition is omitted, and when the joint is being made a clay band is put round where shown, previous to the cement liquid being run in. Or, if desired, the whole of that part of the socket not occupied by the composition can be filled in with cement in a stiffer state in the usual way.

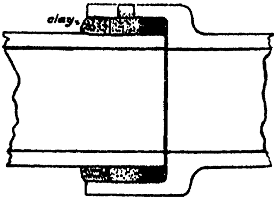

FIG. 172.

(*f*) Fig. 173 is Sykes' patent screw joint, the Albion Clay Co., Limited. Much has been expected from a joint embodying the principle of the screw in some form, and as early as 1862, Doultons exhibited pipes with a screw thread formed in the stoneware itself, at the socket and spigot, a washer being compressed between the ends of the pipe, when screwed up. The example illustrated has had a share of success, the screw collar, both on the spigot and in the socket, being of Stanford's composition cast on, this allowing a certain degree of flexibility when screwed up. The actual joint is effected by the compressed material shown where the edge of the socket comes against the spigot shoulder.

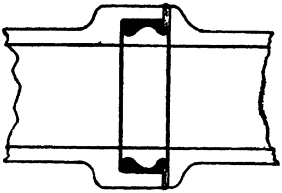
FIG. 173.

(*g*) Fig. 174 shows the "Paragon" patent pipe, which is made with sockets concentric to the pipe. The object of this is to get a true line or invert along the lower inside surface of the pipe without depending on the jointing material to lift the spigot up and bring the surfaces in line. On the right side of the illustration is a section through the socket and spigot as they come together, and on the left will be seen how true the line of the inner surfaces is, though the spigot is not in the centre of the socket. A joint of this kind is to some extent an acknowledgment that the under sides of the ordinary cement joint are often neglected, for it is not over convenient to get at them as a rule, yet notwithstanding this, none but the worst of workmen are guilty of neglect of this kind. The joint is made with cement, much in the same manner as an ordinary socket joint.

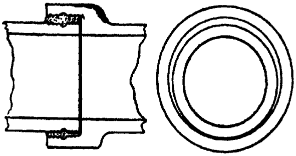
FIG. 174.

There are many other joints besides those noted, but what have been described embody the general principles and ideas that enter into the construction of these special pipes. The writer has no wish to depreciate the value of special joints for purposes they may be particularly adapted for or for every day use, but under ordinary conditions he finds a cement joint, well made, is reliable and remains sound; more than this is scarcely needed, especially as it is the least expensive of any.

Methods of Testing.—The methods of testing the sanitary arrangements of a house are practically confined to three: viz. the hydraulic, or water test, the smoke test, and the odour test. There is also the air-pressure test, but, in the writer's opinion, it should neither be recommended nor used. It is too severe, being a test that for several reasons, not readily discernible to the average plumber, can make good work appear to give very doubtful, if not bad results. It cannot be called a simple test on this account, for it requires skill and care to judge whether a fall in the gauge is due to faulty work or other causes. The first of the three tests above named is only applied to the drainage system as a rule, whereas the two latter are sometimes utilised for the whole work. (*a*) The water test for drainage is undoubtedly the most reliable, and will more readily and certainly show if there is a leakage; but with underground work the point where the leakage occurs may be out of sight and difficult to locate—that is, a little more so than with smoke or odour. For certainty of results, however, as just stated, water should be the medium employed when testing lines of drains. With new work the system is tested with water before the pipes are covered in (all authorities now insist on the hydraulic test), and this test should include filling the chambers or manholes as well as the lines of pipes, so that the entire system contains water and is under pressure.

The writer considers that a pressure of 4-feet head of water is amply sufficient; so that in instances of the drainage system having a total fall of more than this, say over 5 feet, it may be tested in two lengths or sections. After this test it is the best plan, with new work, to test again when the pipes are concreted and finally covered in, as it oftentimes happens that this latter work brings about a leakage, depending, of course, on how carelessly it may be done. With the first test leakages can be looked for at the uncovered joints, but on testing covered work, a leakage can only be discovered by watching the level of the water at the highest point. It is, of course, desirable to include the chambers and manholes in the test, and by including these it is not always necessary to test the drains in sections. Testing separate lengths of drains may become necessary with covered work to locate a single leakage; for should the water test, when applied to a complete system, new or old, show that a leakage exists, it does not follow that the whole of the drains must be condemned, although this may be correct sometimes. This is a question that cannot always be decided easily without uncovering some of the work, but much can be judged by ascertaining the age of the system, and whether originally executed by reliable people, etc. When testing new work it may not be a joint or joints that permit of water escaping, for unfortunately the pipes themselves may be at fault. Reputable makers of earthenware pipes are now alive to the fact that their goods will most probably be subject to the hydraulic test; but in the past, and even now, pipes that are porous and allow water to ooze through them are frequently found. Others, again, if not leaky, will absorb a deal of water when new. The quality of a pipe is generally judged by its thickness, and as London made pipes are usually thicker than those of country manufacture, the former have preference for good work. The best makes of pipe have a thickness calculated on their diameter. A bad pipe is sometimes a trouble of no mean order, for in a length of drainage it is difficult to remove and replace one of the pieces, that is, to make a good and workmanlike job of it again.

This method of testing is apparently simple, but depends upon circumstances. Commonly it is a comparatively easy task, for the principle is simple; the application is, however, sometimes troublesome, but this is only owing to structural difficulties, usually more often experienced in town houses than in the country. The principle, as stated, is simple, as it only requires that the lower end of the drainage system be exposed (if not in a disconnecting chamber as it should be), and this end is then carefully plugged off.

This should be effected by a properly made drain stopper, the screw stopper with expanding rubber ring, or Jones' bag stopper, which is a rubber bag, with tubing attached, for inflation by a small air-pump. This stopper is easily folded up to carry, and has the advantage of suiting more than one size of pipe, or can be used in traps or awkward places. If no stopper is available then any means can be adopted that will make the outlet water-tight and sound. A wood plug with cloth or brown paper round it, a good ball of clay, or a piece of slate cut circular and plastered in, will all do if nothing better is to be had. When this opening is stopped, the system is filled with water, and the water level at the highest point carefully marked and watched. The marking can be easily and very correctly effected by a piece of gummed stamp edging, marked with a pencil after securing it where required.

(*b*) Smoke testing, for soil pipes, branches and fittings is best effected by a machine. The test is commonly applied by charging all parts with smoke and noting if any escape at any point. The smoke is made to enter the drain by an opening, or it may be driven in through a fresh air inlet, or again, through the trap of the lowest w.c. (after soaking out the water with a cloth), or a gully trap with the water removed; but where possible, in country houses for instance, it is best to have the machine away from the house so as to avoid the possibility of any smoke entering or being noticed other than that which may enter by reason of bad or defective work.

The machines are constructed to burn prepared paper, oily waste, or similar material giving off abundance of pungent smoke, and this is delivered through a flexible tube (or a piece of lead pipe) connected from the machine to the chosen opening; this opening must be made air and smoke tight around the pipe, by means of cloth or other material, after which the bellows or fan of the machine is worked. The action of the machine is to draw in fresh air by the inlet opening and expel it, with smoke from the smouldering material, through the connecting pipe to the drain. When effecting the test in this manner, all ventilating pipes must be plugged; but it is necessary to delay doing this until smoke is seen issuing from them. If this precaution is not taken the air with which the soil pipes, etc. are charged cannot well be expelled to make room for the smoke. Or should there be faults by which the air can escape as the smoke enters, it delays results materially, as nothing can be detected until the smoke has reached all points and comes through the faulty places, if any.

The writer's chosen way of effecting the smoke test ensures the machine being outdoors—which is an important advantage—whether the house be in town or country: this is, to make the test from the roof, sending the smoke downwards through the soil pipe, etc. In town houses, it is, otherwise, so often necessary to have the machine inside the building, or, if outside, it is very close to windows and doors (where air is always entering). The lighting, starting and recharging of the machine can scarcely be effected without a distinct escape of odour, giving misleading results—which is a fault of the worst kind in this work. By working from the roof, it will be found that the odours rise away from the building, if ordinary care is used to keep the machine from attic windows or other openings.

(*c*) The odour test relies for efficiency on the escape, through faulty places, of a distinguishing odour from a material put into the drain. The smoke test answers largely to this description, but there is also a visible result with the smoke as a rule. Smoke rockets are more relied on to give an odour than visible smoke; but the best odour test, in the writer's opinion, is effected with Kemp's Chemical Tester, a small device which is decidedly convenient and as effective as an odour test can possibly be. This tester has one very important advantage in not spoiling or deceiving the operator's sense of smell. With peppermint and some other tests there is every likelihood that the person handling the material is of little use in seeking for the odour in the house, and a second man who has not been in contact with, or affected by the odour of the testing material, is necessary in smelling out the possible defective points. The tester now being recommended gives a strong pungent odour, but the device makes it comparatively easy to get the material into the soil or drain pipe without the smell being had beforehand or carried about on the hands or clothes. The method of using this tester is described below.

It remains to be said that an odour test may not always give immediate, or even moderately quick results, unless at exposed pipes or fittings (which are faulty). When used with covered work it may be hours before the full effect is noticeable, depending on the thickness of the superincumbent material, its density, etc. Odour tests, however, though useful, should not be resorted to unless water and a smoke machine are really unavailable. Certainly, if a fault is discovered with a properly conducted odour test there need be no hesitation in pronouncing it a fault, as the test is, in a general sense, the least severe of all.

Testing Apparatus.—(*a*) Fig. 175 illustrates the "Eclipse" smoke-testing apparatus (T. and W. Farmiloe, Westminster). This machine consists of a double-action bellows, and a round copper cylinder, fixed in a square copper tank, containing water. The force from the bellows is sent into the round copper cylinder, in which the smoke is created, the smoke being then driven into the drains by the continued action of the bellows. As the smoke pressure increases on the drain, the copper cylinder will rise in the water, and by the rising and falling of this cylinder, the soundness of the drain may be arrived at. The greater the leak, the quicker the cylinder will fall; or, if the drains are perfect, the cylinder will remain stationary, at the level the bellows may have forced it to.

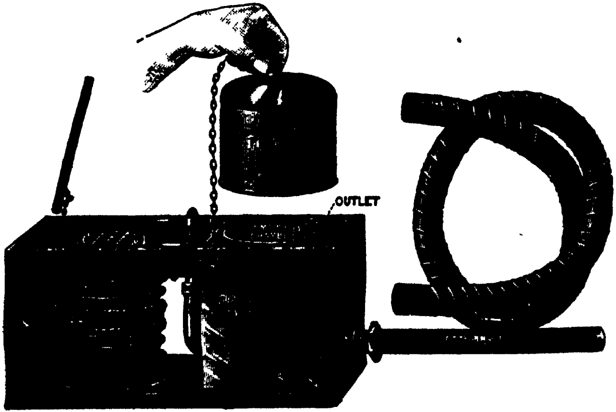

FIG. 175.

Fig. 176 shows the working principle of the "Smoko" testing-machine (Farmiloe). This somewhat resembles the preceding in having a rising smoke-bell or holder, and when supplied complete it has a specially formed drain-pipe stopper, which admits of the hose being connected and the smoke being blown through as Fig. 177. When about to test, the following procedure should be observed. Insert the screw stopper of the size required in the drain pipe, tighten up with the key and couple the armoured hose to same. Fill the water channel C to within an inch of the top, light the end of the cartridge G with a burning candle or paper; place the same, with lighted end downwards, in the fire-box B. Quickly replace the float D, and work the pump gently. To ascertain if the cartridge is burning turn on the tap E.

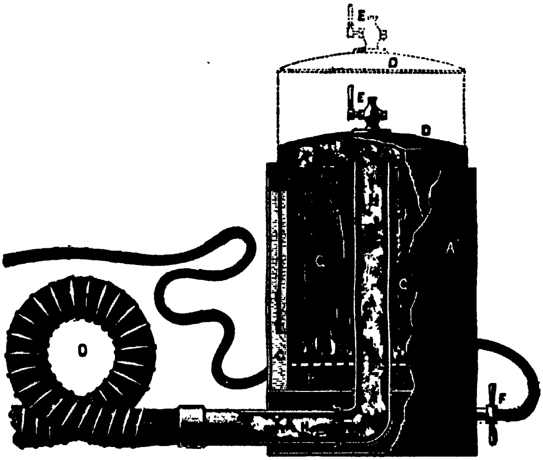

FIG. 176.

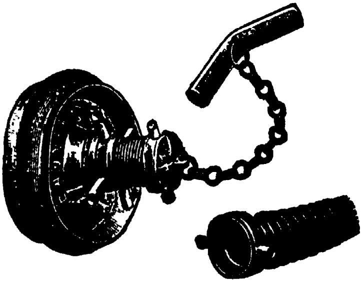

FIG. 177.

As soon as smoke is seen issuing from the tops of vent pipes or fresh-air inlets, they should be stopped up by inflating the air-bags in them.

If the drain is sound the float D will rise, as shown by dotted lines, by the compression of air and smoke (similar to a gasometer), and should remain stationary if the tap is shut off. If the float will not remain suspended or rise at all it is a true indication that the drain or pipe under test is in a leaky condition, and the defects can be traced out by the escape of smoke at such places. Where there is no inspection chamber, the test can be applied through a gully-trap.

This machine can be fitted with a pressure-gauge if desired, so as to register the smoke pressure, when any particular test pressure is specified. The directions in such a case are as follows : After the drain or pipe has been filled with smoke, and extra pressure is required, the float D should be removed, and the pressure-gauge screwed to the top of the smoke-pipe H ; disconnect the air-tube at F, and attach the same to the tee-piece of gauge. By working the pump the indicating hand will rise and remain stationary, if the pipe or drain is sound, and the tap is turned off; when there are defects the hand will fall, or refuse to rise at all, and leakages should be searched for. If there are w.c.'s or other traps connected to the drain under test, they must be stopped by air-bags, as the ordinary seal in such traps will not resist a quarter pound on the pressure-gauge.

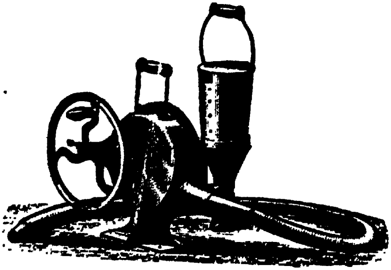

FIG. 178.

This machine is sold to be worked either by a bellows or by a small hand pump.

(b) In Fig. 178 is illustrated a form of rotary-pump testing machine. This has a pot to receive the smoke-producing substance, while the air-current is induced by a revolving fan or air propeller. Needless to say these examples only represent a small proportion of the many on the market, but all entitled to be called machines may be broadly divided into two kinds, viz. those that have the air driven through as a blast by pump or bellows, and those that have the air pass through as a current induced by a rotary blower.

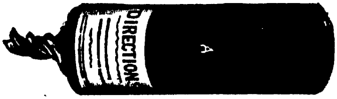

FIG. 179.

(c) For testing without a machine there are appliances or "testers" to produce smoke and smell, like the "Rocket," Fig. 179 ; and chemical testers which create an odour only. The rocket (which is quite stationary when in use) is a kind of firework which, after having its touch-paper end ignited, quickly sends forth a great volume of strong-smelling smoke. In use it may be applied to the end of a pipe in an inspection chamber, or the water may be soaked out of a gully-trap, or w.c. trap, and the rocket be inserted here. Before it is lighted it must be wrapped round thickly with rag (or clay could be used), so that on inserting the lighted end of the rocket the space around, between the rocket and the pipe, is quite filled. In other words the rocket with its wrapping of rag or clay acts as a soundly fitting-plug to the pipe. The rocket then discharges its smoke without loss, and the discharge causes a slight pressure in the drainage system, which is desirable.

(c) Fig. 180 illustrates Kemp's

Chemical Tester, a tester that probably has more use than any other. The writer has used large numbers and considers it very convenient and effectual.

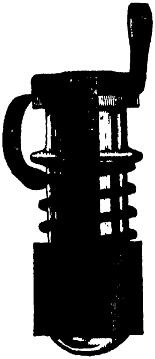
FIG. 180.

One great advantage is that there can be no escape of odour except at faulty points. The operator is at no risk of getting his sense of smell blunted when handling the tester or putting it to work. The writer does not know what material the tester is charged with, but the resulting smell when it does come, is the pungent unmistakable odour of acetylene.

The operation of this tester has already been described, but it may be explained that in the loose cap of the tester there is a coil of fine twine one end of which is attached to the cap, the other to the body. The cap is held in the hand (or tied to something) while the body is dropped into the w.c. trap and immediately washed through the trap with a pail of water, preferably hot. This wetting, within about a minute, causes a gummed strap to give way, and the tester then precipitates its contents. Although the tester is only about 2 in. long, it yields an odour that will extend a great distance, and last quite 2 hours. After about half-an-hour (or less) the tester, or its remains, can be drawn back through the w.c. trap by means of the attached string and a glance will show if it has acted properly. This is the purpose of the string, it enabling the operator to see whether the absence of smell is due to the perfect

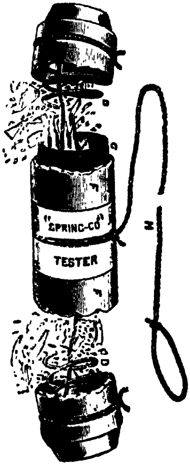

FIG. 181.

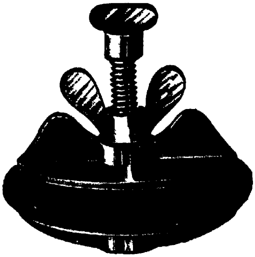
FIG. 182.

condition of the sanitary system, or to an imperfect tester.

(*d*) Fig. 181 is another tester of the kind, called the "Spring-go." This illustration serves to show how such testers act shortly after being wetted. The necessary string is also shown.

open-ended round pipes. For traps and awkward places the bag-stopper is used. This, as will be seen, is a rubber bag, that when uninflated, can be inserted almost anywhere, after which the air-pump fills it and stops the pipe or passage it is in. Fig. 184 is a circular stopper with its centre part so made that the hose of a smoke machine can be attached and the smoke blown through (see also Fig. 177).

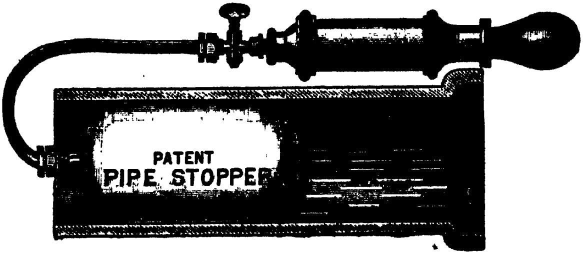

FIG. 183.

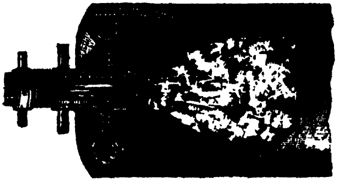

FIG. 184.

Drain Stoppers.—With practically all smoke tests, conducted with machines, also with water tests, one or more drain-stoppers are needed. There are two representative kinds, one being an expanding circular stopper, as Fig. 182, while the other is termed a "bag-stopper," as Fig. 183. The former consists of two metal discs with a rubber collar between the edges (see also Fig. 182), the size of the rubber collar admitting of its easily entering the pipe when the discs are apart, but being compressed out nearly an inch, when the discs are drawn together by the compression screw. This makes a sound stopper, but is only suited for

DRAWING,

IN INK AND COLOURS.

(*See also* ART ENAMELLING, CAMERA LUCIDA, CAMERA OBSCURA, COPYING, ETCHING, PAINTS, POTTERY, ETC.)

Drawing Paper.—The following table contains the dimensions of English drawing-paper :—

	inches.		inches.
Demy	20	by	15½
Medium	22	,,	17
Royal	24	,,	19½
Imperial	31	,,	22
Elephant	27	,,	23
Columbier	34	,,	23
Atlas	33	,,	26
Double Elephant	40	,,	27
Antiquarian	53	,,	31
Emperor	68	,,	48

Reeves state that drawing paper should not be kept damp too long a time (as, for instance, a sketch-block in a tin case with other wet sheets), as the size, with which the paper is prepared, being an organic matter, will perish, due to a minute fungoid growth. Care must also be used in storing paper in a positively dry place when near the sea, otherwise defects may arise that will not show until the artist's work is commenced. Drawing papers, even the best qualities are made in three or four thicknesses and with three surfaces, viz. hot pressed or smooth, not hot pressed (natural surface), and rough. The grain of a heavy paper is always coarser than that of a light paper. There are also papers made expressly for crayon or pastel work.

For making detail drawings a less expensive paper is used, termed "cartridge"; this answers for line drawings, but it will not take colours or tints so well. A good quality, however, called "cartridge for brush-work" can be obtained. Continuous cartridge paper is also much used for full-sized mechanical details, and some other purposes. It is made uniformly 53 in. wide, and may be had of any length by the yard, up to 300 yards.

For plans of considerable size, mounted paper is used, or occasionally the drawings are afterwards mounted on canvas or linen.

For small black and white drawings, such as are made in great numbers for magazines and trade journals, a "board" is made in many sizes. These are a moderately thin cardboard with pure white smooth surface and are very convenient. For anything up to 12 in. the writer much prefers them to paper. Pads of drawing paper in many sizes can be obtained for sketching, and, for outdoor work, in pencil, ink or colours, are particularly useful.

Mounting Drawings or Paper on Linen.—The linen or calico is first stretched by tacking it tightly on a frame or board. It is then thoroughly coated with strong size, and left until nearly dry. The sheet of paper to be mounted requires to be well covered with paste; this will be best if done twice, leaving the first coat about ten minutes to soak into the paper. After applying the second coat place the paper on the linen, and dab it all over with a clean cloth. Cut off when thoroughly dry. (*And see* COPYING.)

Fastening Paper on a Drawing Board.—The stretched irregular edges of the sheet of paper are cut off against a flat ruler, squaring it at the same time. The sheet of paper is laid upon the board the *reverse* side upwards to that upon which the drawing is to be made. It is then damped over, first by passing a moist clean sponge, or wide brush, round the *edges* of the paper about a inch and a half on, and afterwards thoroughly damping the whole surface except the edges. Other plans of damping answer equally well; it is only necessary to observe that the edges of the paper should not be quite so damp as the other part of the surface. After the paper is thoroughly damped, it is left until the wet gloss entirely disappears; it is then turned over and put in its position on the board. About half an inch of the edge of the paper is then turned up against a flat ruler, and a glue-brush with hot glue is passed between the turned-up edge and the board; the ruler is then drawn over the glued edge and pressed along. If upon removing the ruler the paper is found not to be thoroughly close, a paper-knife or similar article passed over it will secure perfect contact. The next *adjoining edge* must be treated in like manner, and so on each consecutive edge, until all be secured. The contraction of the paper in drying should leave the surface stretched quite flat.

Cutting Pencils.—If the point is intended for sketching, it is cut equally from all sides, to produce a perfectly acute cone. If this be used for line drawing, the tip will be easily broken, or otherwise it soon wears thick; thus, it is much better for line drawing to have a thin flat point. The general manner of proceeding is, first, to cut the pencil, from two sides only, with a long slope, so as to produce a kind of chisel-end, and afterwards to cut the other sides away only sufficient to be able to round the first edge a little. A point cut in the manner described may be kept in good order for some time by pointing the lead upon a small piece of fine sandstone or fine glass-paper; this will be less trouble than the continual application of the knife, which is always liable to break the extreme edge.

A most useful pencil for indoor work is that with a hexagonal wood handle, and metal top, which takes loose stick leads. To sharpen this, a strip of fine glass or emery paper mounted on a card or slip of wood, excels all other methods, for by no other means can so long and good a point be made. The emery paper is laid down and the pencil rubbed on it.

Erasing Errors.—To erase lead-pencil marks, rubber answers perfectly. What is found best for this purpose is the comparatively new composition rubber (made in red and white) which is soft and slightly "crumbly." It can be obtained of all good artists' materials warehouses; this besides being a powerful eraser, has the quality of keeping clean, as it frets away with the friction of rubbing, and presents a continually renewed surface to the drawing; the worn-off particles produce a kind of crumb easily swept away. This rubber is also useful for cleaning off drawings, as it will remove any ordinary stain.

For erasing ink lines, the point of a penknife or erasing knife is commonly used. A much better means is to employ a piece of fine glass-paper, folded several times, until it presents a round edge; this leaves the surface of the paper in much better order to draw upon than when erasures are made by a knife. Fine size applied with a brush will be found convenient to prevent colour running. For reproduction work, in publications, editors are divided as to whether errors in ink shall be erased, or whether they shall be marked out with Chinese white. The latter was the rule at one time, but not always so now. In working for publishers this should be ascertained.

To produce finished drawings, it is necessary that no portion should be erased, otherwise the colour applied will be unequal in tone; thus, when highly-finished mechanical drawings are required, it is usual to draw an original and to copy it, as mistakes are almost certain to occur in delineating any new machine. Where sufficient time cannot be given to draw and copy, a very good way is to take the surface off the paper with fine glass-paper before commencing the drawing; if this be done, the colour will flow equally over any erasure it may be necessary to make afterwards.

Where ink lines are a little over the intended mark, and it is difficult to erase them without disfiguring other portions of the drawing, a little Chinese white or flake-white, mixed rather dry, may be applied with a fine sable brush; this will render a small defect much less perceptible than by erasure.

Whenever the surface of the paper is roughened by using the erasing knife, it should be rubbed down with some hard and perfectly clean rounded instrument.

Buying Drawing Instruments.—Persons with limited means will find it better to procure good instruments separately of a respectable maker, Stanley or Harling for instance, as they may be able to afford them, than to purchase a complete set of *inferior* instruments in a case. With an idea of economy, some will purchase second-hand instruments, which generally leads to disappointment, from the fact that inferior instruments are manufactured on a large scale purposely to be sold as second-hand to purchasers, principally from the country, who are frequently both unacquainted with the workmanship of the instruments and with the system practised.

Inferior instruments will never wear satisfactorily, whereas those well made improve by use, and attain a peculiar working smoothness. The extra cost of purchasing the case and the nearly useless rules, would, in many instances be equal to the difference between a good and an inferior set of instruments without the case. Instruments may be carefully preserved by merely rolling them up in a piece of wash leather, leaving space between them that they may not rub each other; or, what is better, having some loops sewn on the leather to slip each instrument separately under.

Drawing Board.—The qualities a good drawing board should possess are: an equal surface, which should be very slightly rounded from the edges to the centre, in order that the drawing paper when stretched upon it may present a solid surface; and the edges perfectly straight, and at right angles to each other.

Using a Drawing Pen.—It should be held very nearly upright, between the thumb and first and second fingers, the knuckles being bent, so that it may be held at right angles with the length of the hand. The handle should incline only a very little—say 10°. The ink generally used is Indian ink, rubbed up fresh every day upon a clean palette. It should be moderately thick, so that the pen when slightly shaken will retain it a fifth of an inch up the nibs. There are, however, numbers of reliable fluid inks ready made, some for brush work, some for pen. The writer uses Reeves' "Fixed Indian Ink," and is satisfied with it. It admits of water or colour being washed over it without running. The pen is filled by means of a quill nib or small camel-hair brush. The edge used to direct the pen should in no instance be of less than one sixteenth of an inch in thickness; a fourteenth of an inch is perhaps the best. If the edge be very thin, it is almost impossible to prevent the ink escaping upon it, with the great risk of its getting on to the drawing. Before putting the pen away, it should be carefully wiped between the nibs by drawing a piece of folded paper, linen, or soft linen rag, through them until they are dry and clean.

Testing the Accuracy of a Straight-edge.—Lay the straight-edge upon a stretched sheet of paper, placing weights upon it to hold it firmly; then draw a line against the edge with a needle in a holder, or a very fine hard pencil, held constantly vertical, or at one angle to the paper, being careful to use as slight pressure as possible. If the straight-edge be then turned over to the reverse side of the line, and a second line be produced in a similar manner to the first at about the twentieth of an inch distance from it, any inequalities in the edge will appear by the differences of the distances in various parts of the lines, which may be measured by spring dividers.

Another method will be found to answer well if three straight-edges are at hand; this method is used in making the straight-edge. Two straight-edges are laid together upon a flat surface, and the meeting edges are examined to see if they touch in all parts, reversing them in every possible way If these two appear perfect, a third straight-edge is applied to each of the edges already tested, and if they touch it in all parts the edges are all perfect. It may be observed that the first two examined, although they touch perfectly, may be regular curves; but if so, the third edge applied will detect the curvature.

Using the Plain Parallel Rule.—One of the rules is pressed down firmly with the fingers, while the other is moved by the centre stud to the distances at which parallel lines are required. Should the bars not extend a sufficient distance for a required parallel line, one rule is held firmly, and the other is shifted, alternately, until the distance is reached.

Using Dividers or Compasses.—It is considered best to place the forefinger upon the head, and to move the legs with the second finger and thumb. In dividing distances into equal parts, it is best to hold the dividers as much as possible by the head joint, after they are set to the required dimensions; as by touching the legs they are liable to change, if the joint moves softly as it should. In dividing a line, it is better to move the dividers alternately above and below the line from each point of division, than to roll them over continually in one direction, as it saves the shifting of the fingers on the head of the dividers. In taking off distances with dividers, it is always better, first to open them a little too wide, and afterwards close them to the point required, than to set them by opening.

Pencilling.—If a drawing could be at once placed to the best advantage on the paper, and surely made without mistake and with all its lines correctly limited when first drawn, it might be made in ink directly on the blank paper. To avoid the errors inevitable in the first copy of any production, even when made by those most practised, drawings are first pencilled and then inked. The whole theory of pencilling, then, is to lay out correct tracks on which the pen is to move, leaving the mind, during the inking, free from all thought of accuracy of the construction, that it may be given to excellence in execution. Therefore, the whole of the pencil-construction should be most accurately made in the finest faint lines with a moderately hard pencil.

Finishing a Drawing.—While "Finish a drawing without any error or defect," should be the draughtsman's best motto, he should never be in haste to reject a damaged drawing, but should exercise his ingenuity to see how far injuries done to it may be remedied. "Never lose a drawing once begun," should be his second motto; and since prevention is easier and better than cure, let him always work calmly, inspect all instruments, hands, and sleeves, that may touch a drawing, before commencing an operation; let the paper, instruments, and person be kept clean, and when considerable time is to be spent upon a portion of the paper, let the remainder be covered with waste paper, pasted to one edge of the board.

For the final cleaning of the drawing, stale bread, or soft rubber, is good; but, aside from the carelessness of ever allowing a drawing to get very dirty, any fine drawing will be injured, more or less, by *any* means of removing a considerable quantity of dirt from it.

Another excellent means of preventing injuries, which should be adopted when the drawing is worked upon only at intervals, is to enclose the board, when not in use, in a bag of enamelled cloth or other fine material.

Lettering.—The title to a drawing should answer distinctly the four questions—*What*, *Who*, *Where*, and *When*—*What*, including the use and scale; *Who*, both as to designer or inventor, and draughtsman; *Where*, both as to the place, institution, or office where the drawing was made, and the locality of the object drawn; and *When*, the date of execution.

If the drawing is perfectly symmetrical, its title should have the same axis of symmetry as the drawing. If the drawing is unsymmetrical, the title may be at either of the lower corners.

These principles do not apply to horizontal views, as maps of surveys, when the title may be wherever the shape of the plot affords the best place.

One quite essential element of beauty in a title is its arrangement, or the *form of its outline* as a whole. It should embrace such variations in the length of its line of letters that the curve formed by joining the extremities of those lines would be a simple and graceful one, having also a marked variety of form. Also the greatest length of the title should generally be horizontal; or its proportions, as a whole, like those of the border of the drawing.

When the occupation of the paper affords only narrow blank spaces lying lengthwise of the paper, the title looks well mostly on a single line at the bottom, the principal words being in the middle, and the subordinate ones at the two sides.

Moreover, horizontal lines should prevail in the direction of the lines of words in the title. Indeed, the title may be arranged wholly on horizontal lines with good effect, though an arched or bow-shaped curve for the principal words may be adopted when the drawing includes some conspicuous arching lines.

The size of the title should be appropriate to that of the drawing. In particular, the rule has been proposed that the height of the largest letters in the title should not exceed three-hundredths of the shorter side of the border. Also, the relative size of the different portions of the title should correspond to their relative importance, the name of the object and its inventor being largest, and that of the draughtsman, his location, and the date of his work being considerably smaller.

Geometrical drawings are *most* appropriately lettered with geometrical letters, which, when neatly made, always look well. Any letters, however, having any kind of sharply-defined and precise form, as German text, are not inappropriate to a geometrical drawing; but vaguely formed "rustic" or other freehand letters are in bad taste on such drawings.

Letters should correspond in conspicuousness or body of colour with the rest of the drawing, not being obtrusive from great heaviness of solid black outline, nor unobservable from excessive faintness. Also, violent contrasts of heaviness among neighbouring portions of the title should be avoided; though there may be a gradual change, both of intensity and size, from the most to the least important words of the title.

This should, first of all, not exceed in elaborateness the draughtsman's ability to execute it with perfect neatness and clearness. Then it should agree with the character of the drawing. Plain and simple letters look best on a similar drawing, while a complicated and highly-finished drawing may receive letters of more ornamental character.

Borders.—For line drawings, the border should be a geometrical design, in lines, with curved or angular corners, or with combinations of straight or curved lines, forming geometrical corner-pieces. These borders may vary in complexity from a rectangular border in single lines to borders which, though geometrical, may be elaborate and elegant. Thus: a plate of varieties of straight horizontal lines may have a plain rectangular border; one including oblique lines may include oblique lines in the border, either as a little tuft in each corner, a truncated corner, or a square set diagonally, etc. Plates embracing curve lines may have quarter-circle borders, either convex or concave inwards—of which the former have most decision. Such plates may also have little circles for corner-pieces. Borders may sometimes conform in a pleasing manner to the general outline of a drawing. Thus, an arched bridge may have a semi-oval upper border and a square-cornered border at the base of the drawing; and an ornamental device may crown the summit of the border.

When the drawing is a shaded one, containing, therefore, some free-hand work, the border may be partly free-hand also; but should still be largely geometrical in its design, and should represent a real border of substantial materials, corresponding to the subject of the drawing. Thus, the mouldings and ornaments should represent ornamental metallic castings, carvings in wood, mouldings in plaster, or scrolls and leaves of rolled metal; but garlands, tassels, and tendrils, etc., should not be introduced.

The border to a geometrical drawing should be like the drawing itself in being executed with the drawing pen and brush, as well as with the mapping pen. Free-hand pen borders, representing the products of the soil, with cornucopias, little pen sketches of scenery, or similar agricultural or landscape devices, worked in as corner-pieces, are more appropriate on topographical drawings.

As to colour, *primary* colours should not be largely introduced into the border; *first*, since they, when obtrusive, are adapted to ruder or less impressible tastes than the secondary hues, shades, and tints, which are more gratifying to delicate tastes; and *secondly*, from the impertinent conspicuousness which they may give to the border.

Drawings which are shaded only in sepia or ink, or any dark neutral tint, may have the border done in the same or in a dark complementary colour. Tinted ink drawings are best finished with a plain ink border.

Indian Ink is used for producing the finished lines of all kinds of geometrical drawing. Being free from acid, it does not injure or corrode the steel points of the instruments. The genuine ink, as it is imported from China, varies considerably in quality, and that which answers best for line drawing will wash up the least when other colours are passed over it. This quality is ascertained in the trade, but not with perfect certainty, by breaking off a small portion. If it be of the right quality it will show, when broken, a very bright and almost prismatic-coloured fracture. Indian ink should be used immediately after it is mixed; if re-dissolved it becomes cloudy and irregular in tone, but with every care, it will still wash up more or less.

Colours.—For colouring drawings, the most soluble, brilliant, and transparent water colours are used; this particularly applies to plans and sections. The colour is not so much intended to represent that of the material to be used in the construction, as to clearly distinguish one material from another employed on the same work.

The following table shows the colours mostly employed by the profession:—

Carmine or Crimson Lake	For brickwork in plan or section to be executed.
Prussian Blue . .	Flintwork, lead, or parts of brickwork to be removed by alterations.
Venetian Red . .	Brickwork in elevation.
Violet Carmine .	Granite.
Raw Sienna . . .	English timber (not oak).
Burnt Sienna . .	Oak, teak.
Indian Yellow . .	Fir timber.
Indian Red . . .	Mahogany.
Sepia	Concrete works, stone.
Burnt Umber . .	Clay, earth.
Payne's Grey . .	Cast iron, rough wrought iron.
Dark Cadmium . .	Gun metal.
Gamboge . . .	Brass.
Indigo	Wrought iron (bright).
Indigo, with a little Lake	Steel, bright.
Hooker's Green . .	Meadow land.
Cobalt Blue. . . .	Sky effects.

And some few others occasionally for special purposes.

In colouring plans of estates, the colours that appear natural are mostly adopted, and may be produced by combining the above. Elevations and perspective drawings are also represented in natural colours, the primitive colours being mixed and varied by the judgment of the draughtsman, who, to produce the best effects, must be in some degree an artist.

Care should be taken in making an elaborate drawing, which is to receive colour, that the hand at no time rests upon the surface of the paper, as it is found to leave a greasiness difficult to remove. A piece of paper placed under the hand and if the square is not very clean, under that also, will prevent this. Should the colours, from any cause, work greasily, a little prepared ox-gall may be dissolved in the water with which the colours are mixed, and will cause them to work freely.

Shading.—For shading, camel or sable hair brushes, called "softeners," are generally used: these have a brush at each end of the handle, one being much larger than the other. The manner of using the softener for shading, is to fill the smaller brush with colour, and to thoroughly moisten the larger one with water; the colour is then laid upon the drawing with the smaller brush, to represent the dark portion of the shade, and immediately after, while the colour is quite moist, the brush that is moistened with water is drawn down the edge intended to be shaded off; this brush is then wiped upon a cloth and drawn down the outer moist edge to remove the surplus water, which will leave the shade perfectly soft.

If very dark shades are required, this has to be repeated when the first is quite dry.

To tint large surfaces, a large camel-hair brush is used, termed a "wash-brush." The manner of proceeding is, first, to tilt the drawing, if practicable, and commence by putting the colour on from the upper left-hand corner of the surface, taking short strokes the width of the brush along the top edge of the space to be coloured, immediately following with another line of similar strokes into the moist edge of the first line, and so on as far as required, removing the last surplus colour with a nearly dry brush. The theory of the above is, that you may perfectly unite wet colour to a moist edge, although you cannot to a dry edge without showing the juncture. For tinting surfaces, it is well always to mix more than sufficient colour at first

Colouring Tracings.—It is always best to colour tracings on the back, as the ink lines are liable to be obliterated when the colour is applied. Mix the colours very dark, so that they may appear of proper depth on the other side. If ink or colour does not run freely on tracing cloth, mix both with a little ox-gall.

Cutting Stencil-Plates.—The perforations are made through the metal, either by engraving, by etching with nitric acid diluted with about one-third water, or, what is better, by both methods combined. If engraving only is employed, the force necessarily applied to the graver will sometimes stretch the plate unequally, whereas by etching alone, the edges of the perforations are left rough, and the corners imperfect; but if the line be lightly etched, and afterwards cleared with the graver, it may be rendered perfect without any risk of cockling the plate. If the back of the plate is smeared with a little oil, the cuttings will come out clean. A good ground for the etching of these plates is made by rubbing on them, slightly heated over a spirit-lamp, a cake of heel-ball.

Copper is much better than brass for stencil-plates; the metal being softer, it lies closer to the paper upon receiving the pressure of the stencilling brush. This close contact is a very important consideration, as it prevents the hairs of the brush from getting under the plate, and producing rough edges.

There is a material known as stencil or *horn* paper, that serves excellently for stencils that will be used but a limited number of times.

Plain stencil alphabets will not be necessary to a draughtsman, if he is a good writer, as they will only save him a little time. A greater saving may be effected by the use of words which are constantly recurring; as ground plan, front elevation, section; or of interiors, as drawing-room, kitchen.

For railway or public works, headings of plans may be cut in suitable character and style; also words which are frequently repeated on any particular works, as the name and address of the architect or engineer.

Besides letters and words, there are many devices by the use of which a superior effect may be produced, and much time saved; of these may be mentioned, north points, plates for the representation of surface of country, as plantation, wood, or marsh, corners and borders for finished plans, and many other devices.

Using Stencil Plates.—The brush requires to be squarely and equally cut, and to be kept moderately clean. If Indian ink is used, the largest surface of the cake should be taken to rub the moist brush upon, to get it equally diffused and softened with colour. A cheap kind of ink is sold with stencil plates, which answers better than Indian ink, as it runs less upon the drawing and presents a larger surface to the brush.

After the plate has been in use some time, the fine lines and corners become clogged with ink, which may easily be removed by soaking the plate a short time in warm water, and afterwards lightly brushing it upon a flat surface until quite clean. It must be particularly observed that a cloth should at no time be applied to the plate either to clean or to wipe it, as this would be almost certain to catch in some of the perforations, and probably spoil the plate.

If the plate by improper use becomes cockled, it may be flattened, if laid upon a hard flat surface, by drawing a cylindrical piece of metal, as for instance, the plain part of the stem of a poker, firmly across it several times on each side of the plate.

In using the stencil plate, hold it firmly to the drawing by *one edge* only, in no instance allowing the fingers to cross to the opposite edge. The general method is, to place the fingers of the left hand along the bottom edge. When the brush is diffused with ink, so that it is just moist, lightly brush it upon a book-cover or pad, so as to free the points of any excess of colour. In applying the brush to the plate, it should be held quite upright, and moved, not too quickly, in small circles using a constant, equal pressure, as light as appears necessary. The stencilling should be commenced at one end of the plate and proceeded with gradually to the other, moving onwards as the perforations appear filled with colour, being particularly careful not to shift the fingers placed upon the plate during the operation. If the plate is very long, after each word the fingers may be shifted, if the plate be held down during the time firmly by the other hand. Should there not be quite sufficient ink in the brush to complete the device, the plate may be breathed upon, which will moisten the ink attached to the plate. If, after the plate is removed, the device appears light in parts, the plate may be replaced and the defects remedied, if very great care be taken to observe that the previous stencilling perfectly covers the perforations.

In stencilling words or numbers with the separate letters of the alphabet, draw a line where the bottoms of the letters are intended to come, take the separate letters as required and place them upon the line, so that the line just appears in the perforations. That the letters may be upright, it is best that the next letter on the slip used should also allow the line to appear in it. The required distance of the letters apart must be judged of by the eye, a pencil mark being made, after each letter is completed, to appear in the perforation on the near side of the next letter to be stencilled.

With care, a stencil plate will last in constant use for many years; without care, it is practically spoilt by taking the first impression.

Removing Drawings from the Board.—Make a pencil line round the paper with the T-square at a sufficient distance to clear the glued edge, and to cut the paper with a penknife, guided by a stout ruler. In no instance should the edge of the T-square be used to cut by. A piece of hard wood, half an inch thick by two inches wide, and about the length of the paper, forms a useful rule for the purpose, and may be had at small cost. The instrument used for cutting off, in any important draughtsman's office, is what is termed a *stationer's rule*, which is a piece of hard wood of similar dimensions to that just described, but with the edges covered with brass. It is necessary to have the edge thick to prevent the point of the knife slipping over. Either of the above rules will also answer to turn the edge of the paper up against when gluing it to the board.

The Frame for a Drawing is to afford a suitable protection to the finished drawing, and hence should be so subordinate in design and colour as not to distract attention from the drawing.

For geometrical drawings, a gilt frame is, in general, preferable to a dark-coloured wooden one. Occasionally the latter style of frame may be appropriate, as in case of a very darkly-shaded drawing on tinted paper, or of a drawing which very completely fills the paper.

It hardly need be said that a frame of plain mouldings is more appropriate for a geometrical drawing than is a carved or stucco-moulded frame. For ordinary geometrical drawings, nothing is prettier than an Oxford frame of light oak, or a plain gold frame.

Vegetable Parchment is made by dipping ordinary paper, for a few seconds, into a solution, containing one part water to six sulphuric acid; then washing it carefully, to remove every trace of acid.

Making Pencil Drawings Indelible.—(*a*) Lay the writing in a shallow dish, and pour skimmed milk upon it. Any spots not wet at first may have the milk placed upon them lightly with a feather. When the paper is wet all over with the milk, take it up, and let the milk drain off, and remove with the feather the drops which collect on the lower edge. Dry carefully.

(*b*) Prepare water-starch, in the manner of the laundress, of such a strength as to form a jelly when cold, and then apply with a broad camel-hair brush, as in varnishing.

(*c*) The same may be done with thin, cold isinglass water or size, or rice water.

Mounting Engravings.—Strain thin calico on a frame, then carefully paste on the engraving so as to be free from creases; afterwards, when dry, give two coats of thin size (a piece the size of a small nut in a small cupful of hot water will be strong enough), finally, when dry, varnish with white hard varnish.

Renewing Manuscripts.—Take a hair pencil and wash the part that has been effaced with a solution of prussiate of potash in water, and the writing will again appear if the paper has not been destroyed. (*And see* INK.)

Uniting Parchment to Paper, or Wood.—(*a*) The surface of the parchment must first be moistened with alcohol or brandy and pressed while still moist upon glue or paste. When two pieces of parchment are to be joined, both must be moistened in this way. It is said that the paper will sooner tear than separate where it has been thus fastened together.

(*b*) Another way is to put a thin piece of paper between the surfaces of parchment, and apply the paste. This forms a firm joint, and can with difficulty be separated. Glue and flour paste are best adapted for uniting surfaces of parchment.

Tracing Paper.—(*a*) Wash very thin paper with a mixture of: Spirits of turpentine, 6; rosin, 1; boiled nut oil, 1, parts by weight, applied with a soft sponge.

(*b*) Brush over one side of a good, thin, unsized paper with a varnish made of equal parts of Canada balsam and turpentine. If required to take water colour, it must be washed over with ox-gall and dried before being used.

(*c*) Open a quire of double-crown tissue paper, and brush the first sheet with a mixture of mastic varnish and oil of turpentine, equal parts; proceed with each sheet similarly, and dry them on lines by hanging them up singly. As the process goes on, the under sheets absorb a portion of the varnish, and require less than if single sheets were brushed separately.

(*d*) Any kind of opaque drawing paper in ordinary use may be employed for this purpose, stretched in the usual way over the drawing to be copied or traced. Then, by the aid of a cotton pad, the paper is soaked with perfectly pure benzine. The pad causes the benzine to enter the pores of the paper, rendering the latter more transparent than the finest tracing paper. The most delicate lines and tints show through the paper so treated, and may be copied with the greatest ease, for pencil, Indian ink, or water-colours take equally well on the benzinised surface. The paper is neither creased nor torn, remaining whole and supple. Indeed, pencil marks and water-colour tinting last better upon paper treated in this way than on any other kind of tracing paper, the former being rather difficult to remove by rubber. When large drawings are to be dealt with, the benzine treatment is only applied in parts at a time, thus keeping pace with the rapidity of the advancement of the work. When the copy is completed, the benzine rapidly evaporates and the paper resumes its original white and opaque appearance without betraying the faintest trace of the benzine. If it is desired to fix lead-pencil marks on ordinary drawing or tracing paper, this may be done by wetting it with milk and drying in the air.

Transfer Paper is made by rubbing white paper with a composition consisting of 2 oz. of tallow, ⅜ oz. powdered black-lead, ¾ pint of linseed-oil, and sufficient lampblack to make it of the consistency of cream. These should be melted together and rubbed on the paper whilst hot. When dry it will be fit for use. (*See* CARBON PAPER IN COPYING.)

Copying Drawings to a Reduced Scale. — Following are methods of copying a drawing to a scale $\frac{1}{m}$ of the original scale by means of an easily-constructed geometrical diagram, which may be found useful to mechanical and architectural draughtsmen — at any rate, in the absence of proportional compasses. Indeed, when m is less than 3, working with a diagram is at least as easy as working with the clumsy instrument just named, and the results are as accurate, supposing the diagram to be carefully constructed.

(*a*) In Fig. 185, let A and B be fixed points in a piece of cardboard or thick drawing paper, and A P, B P, any two lines drawn from them and meeting in P. Then, if in all cases A P = m . B P, the locus of P is a circle whose centre (T) is on A B produced.

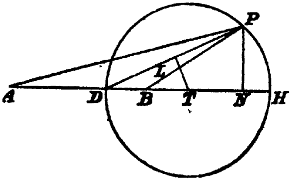

FIG. 185.

To prove this, draw P N perpendicular to A B, or A B produced. Let B N = x, N P = y, and consider the length of A B (the *base*) as representing unity. Then—

$$y^2 + (x+1)^2 = m^2(y^2 + x^2)$$

from which we derive—

$$y^2 + \left(x - \frac{1}{m^2 - 1}\right)^2 = \frac{m^2}{(m^2 - 1)^2}.$$

This is the equation to a circle, $BT = \frac{1}{m^2 - 1}$, and the radius $TP = \frac{m}{m^2 - 1}$. By giving to m different values, we can calculate the corresponding values of B T and T P. Thus, if $m = \frac{\sqrt{3}}{\sqrt{2}}$, which is the ratio used in isometric projection, it will be found that $BT = 2$, and $TB = 2{\cdot}45$. If $m = \frac{3}{2}$, $BT = 0{\cdot}8$, and $TP = 0{\cdot}67$, etc. The difference between the shortest length, A D, that can be taken on the original drawing and A H, the longest, decreases as we increase m, and it is easily shown that the range of the instrument, in its most simple form, is expressed by the formula—

$$AH = \frac{m+1}{m-1} . AD.$$

In practice it is rarely necessary to calculate numerically the lengths B T and T P, for by a simple geometrical construction we are enabled to produce a diagram to any ratio m, given two lines whose lengths are in that ratio. Thus, suppose A B to be a suitable length for the base, and A P to equal $m . BP$. Bisect the angle A P B by the line P D. Then, since, by Euclid VI. 3—

$$AD : DB :: AP : BP$$
$$\therefore \; AD : DB :: \; m : 1,$$

which shows that P D is a chord of the required circle. Bisect P D in L, and draw L T perpendicular to P D. Evidently T, since it lies on both L T and A H, must be the centre, T P being the radius. Describe the circle, and the diagram is complete.

The mode of using the diagram requires little explanation. A length A P, from the original drawing, being set off with ordinary compasses from A, determines the position of the point P, and we take P B for the corresponding length in our copy. To prevent their being holed by compass points, A and B ought to be protected by horn centres.

For any measurement shorter than A D, when it cannot be taken indirectly (that is, as the difference between two longer measurements), a supplementary circle, constructed to a shorter base than A B, is required. In the diagram, Fig. 186, from A draw any line, $Ah = AD$, the shortest of the measurements; join Hh, and through T, B and D draw lines parallel to Hh, meeting Ah in t, b, and d respectively. Then, Ab is the new base, and t the centre of its circle, of which the radius is td. Supposing A B to be of sufficient length, a third circle and base can be derived from the second, a fourth from the third, and so on; and it is easy to see—since the two circles in the figure are tangential to the arc fDh, described from A as a centre with the radius A D—that any measurement found on one circle cannot be found on any other, and therefore that no doubt need occur as to which base a measurement applies to. When there are but two circles and bases, as in Fig. 186, since $Ah = AD$, we have

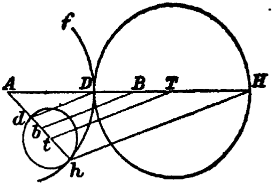

FIG. 186.

$$AD = \frac{m+1}{m-1} . Ad,$$

and

$$AH = \frac{m+1}{m-1} . AD,$$

$$\therefore \; AH = \left(\frac{m+1}{m-1}\right)^2 . Ad.$$

In practice more than two circles are rarely required; but if we had n circles, and l and s were the greatest and least measurements within the range of the instruments, then—

$$l = \left(\frac{m+1}{m-1}\right)^n . s.$$

(*b*) Suppose that the drawing is to be reduced to three-fourths, draw a straight line A B (Fig. 187) of any length. From any point A drop a perpendicular A C at right angles to A B. Lay off on A C a convenient distance A D. Then with D as a centre and radius of a length of which A D is three-fourths the original drawing, cut A B in E, join D E and the diagram is completed.

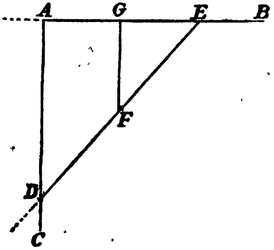

FIG. 187.

If any dimension E F from the original drawing is with compasses applied from E along E D, then F G will be the reduced dimension.

It is not necessary in practice to draw the line F G, as, by oscillating the point of the compasses, the point of perfect contact will be easily got, and will be the required reduction. The lines A B and D E may be produced in the direction of the dotted lines, thereby enabling the draughtsman to measure longer distances than that for which the diagram was at first constructed, should occasion require.

DRYING AND DESICCATING.

(*See also*
EVAPORATING, PRESERVING, ETC.)

ALTHOUGH drying and desiccating are terms which have the same meaning, viz. the removal of moisture from wet or damp goods, yet in trade application the drying of goods does not necessarily mean the removal of every particle of moisture, whereas desiccation applies more to processes by which substances are dried to the utmost extent short of burning them. The same kind of appliance may therefore serve for either, though this is not the case always. Drying rooms, with which this subject commences, could scarcely be considered suitable for desiccating goods as ordinarily understood.

(*a*) **Drying Rooms.**—The process of drying in rooms prepared for this purpose depends on the fact that air can and will readily pick up or absorb moisture, much as an absorbent material will. There is, however, a limit to the water-holding capacity of air, and it is necessary in the first place to introduce air which is deficient in moisture, and then, when it has absorbed what it can, to carry it away. The drying capacity of air is the difference between the moisture it contains and the amount required to saturate it; by saturation being meant the utmost capacity the air has for moisture. When air has taken up all the moisture it can, it is said to be saturated, and can absorb no more, and if by chance it has more than it can hold, its dew point, the point at which air deposits moisture, will manifest itself.

A table showing the moisture capacities of air at different temperatures is here given, and it will be seen that at high temperatures the vapour held is out of relative proportion. For instance, a rise of 30° from 30° to 60° F. allows of an increase in the water held of 3·60 gr. per foot, but a rise of 30° from 60° to 90° F. shows an increase of 8·39 gr. By this it will be seen that a great economy and effectiveness is obtained with a high temperature, and, roughly, it can be computed that the drying capacity of the air is doubled with each rise of 27° temperature. As a rule 130° F. is considered the best temperature for ordinary laundry goods, doing no injury to the goods and proving very satisfactory. The temperature may fall 30° when the wet clothes are first put in, but it gradually rises again as the goods become dry.

THE QUANTITY OF WATER THAT AIR IS CAPABLE OF ABSORBING TO BECOME SATURATED.

°F.	Gr. per Cu. Foot.	°F.	Gr. per Cu. Foot.	°F.	Gr. per Cu. Foot.	°F.	Gr. per Cubic Foot.
10	1	45	3⅝	85	12⅜	141	58
15	1⅜	50	4⅜	90	14⅛	157	85
20	1⅝	55	5	95	16⅝	170	112⅜
25	1⅞	60	5⅞	100	19⅛	179	138
30	2⅛	65	6⅞	105	22	188	166
32	2⅜	70	8	110	25⅜	195	194
35	2⅝	75	9⅜	115	30	212	265
40	3	80	10⅝	130	42⅜		

Note.—The atmosphere, whatever its temperature is never quite saturated. Its humidity varies, according to the time of year and the weather, from 75° to 90° of complete saturation.

The successful working of a drying room is best obtained by stove-heated air, if care is exercised in preventing the air reaching too high a temperature. Next to this come high-pressure hot water and steam, lastly, low-pressure hot water. There is no objection to the nature of the heat furnished by either, but with the last an expensive quantity of pipe would be needed to keep a free supply of new air constantly at 130°. In any case, it is of the highest importance that moisture be not added to the heated air. There must be no vaporising trough which provides humidity to the warmed air supplied to rooms; it must be delivered into the chamber as dry as possible (and it will be very dry if heated from, say 50° to 130° without the addition of moisture), and it must not stay long there.

It is of practically no use whatever to heat the air of a drying room, if it is not allowed or caused to escape as soon as it is saturated, or nearly so. In other words, full and free ventilation is of vital importance in obtaining success. Quite large numbers of instances have met the writer's notice in which a full degree of heat has been supplied by pipes, but no ventilation. In other cases there has been an outlet ventilator for the escape of the wet air, but, as no inlet was provided, the air did not move. In still other cases there have been inlets and outlets, yet no movement of air, as the vents were merely holes. If the air is to move, some force must be brought into play to impel it. The outlet may be a chimney to induce a draught or the air may be extracted by a fan. In case of stove heat, if the furnace is a few feet below the room the warm air duct may create a sufficient velocity to the air to make a plain hole act as an outlet to the room. This is supposing the room stands quite clear of surroundings, and will get no down-blow or back currents of external air.

Another detail to ensure effectiveness is to arrange the inlet and outlet so that the air will have contact with, surround and penetrate every article that is to be dried, and this is best done by having both inlet and outlet at the bottom of the room. Fig. 188 shows one way of doing this (with stove-heated air) by which a uniform diffusion of the hot dry air is made very certain, and it seems impossible that any part of the chamber can escape being affected by the air that passes through it. It will be seen that the inlet is by a pipe coming through the floor, and the outlet, which, although leading away from the top, really starts from two or more points near the bottom of the room by the tubes shown. At the junction piece at the top is a valve or adjustable register, which can be opened to start the draught in the outlet shaft when desired, but at other times it is closed.

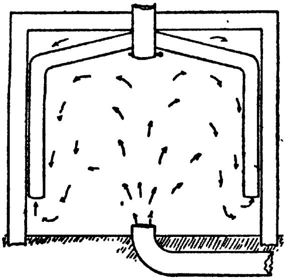

FIG. 188.

The arrows in the illustration show the direction of the heated air when this ceiling register is closed and the room is in normal use.

Fig. 189 shows the method adopted by the writer in heating and ventilating a drying room for wet fibre goods used in fine brush making. The material was spread out on wire trays,

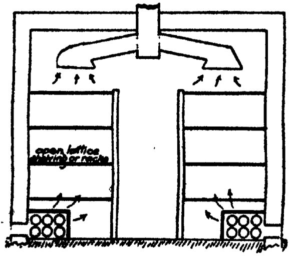

FIG. 189.

these being placed on very open lattice shelves. The available heat was steam at 30 lb. pressure, and it was found that six rows of 3 in. pipe on each side of the room, which was 10 ft. wide served well. The pipes were encased with partly grated casings, the purpose of the cases being to ensure that the air coming in through the inlet openings should have close contact with the pipes.

The minimum size of fresh air duct and outlet shaft should be one square foot area for every 500 cub. ft. of space in the room (when empty),* this being a room, say 8 ft. each way; and the outlet shaft should be at least twice as high as the room, say 16 ft., or higher. With a higher shaft a smaller area would suffice. It may seem needless to impress on readers that the fresh air must be absolutely clean, for laundry work at least, and for this purpose it becomes essential to filter the air (at the cold inlet) if the work is in a populated place. Even with a very pure, unpolluted country atmosphere, a wire-gauze strainer is needed to arrest particles of flying material and insects. The filtration is effected with cotton wool, cheese cloth or muslin, and it is very necessary that the user quite understand that the filter merely arrests impurities and holds them, so that the renewal of the filtering material must be done at regular periods, which are governed by the condition of the atmosphere. Damp, without dirt, will clog the pores, which would make it appear that the filter had better be on the warm air side of the heating chamber, but this is never done.

When heating a drying room by hot water or steam the detail of ventilation and air movement must be considered differently. One of the chief objects of the heated pipes is to warm the air so as to increase its capacity—its thirst—for moisture. To warm the goods effectively, and let the air get warmth the best way it can, is working on a wrong principle, although it is often done. Heat has no capacity for water, neither have the walls of the room nor the pipes. It is the air and the air only that will rob the clothes or goods of moisture; but its power to do this, as already stated, is so very much less when the air is cool than when it is hot. Effort must be made to warm the air, this warmth giving it a dryness and affinity for water, and this in turn being satisfied by the water from the goods that require to be dried. Heat without ventilation will not dry goods. It might convert some of the moisture into what might be called steam vapour, but unless this was carried away it would be redeposited on the goods when the temperature fell.

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* These sizes are for drying rooms for wet clothes, which are about the wettest goods that are treated in this way. For substances of a drier nature, smaller ducts and shafts, with a corresponding decrease in the air supply, may be used.

(*b*) The process of drying depends on the fact that heated air will absorb moisture as a sponge absorbs water. When air has taken up all the moisture that it can, it is said to be saturated. The drying capacity of air is the difference between the amount of moisture contained and that required for full saturation. In general terms air containing 85 per cent. of moisture is called damp; 65 per cent., moderately dry; 50 per cent., dry; 35 per cent., very dry; and 25 per cent., extremely dry. The drying capacity of air increases with the temperature, a cub. ft. at 30° F absorbing about 2·19 gr. of water, while at 130° it will take up 42·5 gr., or about 20 times as much; this shows the advantage of heating air for drying to a moderately high temperature.

For each increase of 27° in the temperature of the air, its drying capacity is doubled; in other words, the capacity of the drying room can be doubled by increasing the temperature of the room 27°. For ordinary laundry work a temperature of about 130° has been found the most satisfactory. When wet clothes are first placed in the room, the temperature falls from 20° to 30°, but gradually moves up again as the goods become dry.

The successful construction of a drying room depends upon plenty of heat and a bountiful supply of fresh clean air. In no system of heating are the benefits of direct radiant heat more manifest than in the drying room; for this purpose the heating surface is most effective when so placed that the direct rays of heat from it will strike on at least one side of the article to be dried. It is, however, of more importance that the air supply should be so arranged that in addition to being brought in direct contact with the heating surface it will also penetrate and completely surround every article to be dried. A rapid moving current of air, say 250 or 500 ft. per minute, according to the articles to be dried, is the most effective. It is for this reason that the month of March is the best time for out-of-door drying.

In drying rooms of ordinary steam laundries as generally constructed, either no provision or one totally inadequate is made for the entrance of fresh air; this, combined with the improper arrangement of entrance and exit openings, when any are provided, results in great waste of heat, likewise fuel and prolongation of time for drying that would otherwise not be required with a properly constructed drying room and loss relative thereto. Many firms manufacturing laundry machinery express their ignorance of this subject by illustrating in their catalogues drying rooms with an exit at top of room only, with no provision for a supply of fresh air. An exit at the top of the room is allowable for just one object; that is, to establish a draught in the vent chimney. After this has got well under way the ceiling exit should be closed and the floor exit used. With the air entering at the floor and with the exit at the ceiling, it will move in a straight line from the inlet to the outlet and become only partly saturated, the result being a loss of heat and fuel. With the inlet and exit at floor, the air is brought in contact with the articles to be dried in both the upward and downward current and being confined longer becomes more fully saturated.

From the above it will be seen that the two points to be looked after in the construction of a drying room are to have sufficient surface to heat the air to a high temperature and to have it so arranged that the radiant heat will be most effective, that is, so that it will strike against all of the articles to be dried if possible ; to have the inlet and main exit at the floor, of ample size and so arranged that the air will not only become thoroughly heated upon entering, but will penetrate and surround the goods to be dried. As an auxiliary to the floor outlet an entrance into the chimney at the ceiling can be made for the purpose of establishing a current, the entrance being provided with a tight fitting damper, which should be closed after starting, as the floor and ceiling exit dampers can be made to operate together, the object being obvious. Drying room closets are generally constructed about 10 ft. high and, when sliding racks are used, about 8 ft. wide, the length varying with the amount of work to be done. In hospital work an allowance of about 1 sq. ft. of drying rack for children, 1½ sq. ft. for men, and 2 sq. ft. for women will generally give satisfactory results.

Drying rooms in which sliding racks are used are generally 10 ft. high by 8 ft. wide or deep, each rack being about 7 by 7 and 1 ft. wide, containing two sets of bars or about 100 sq. ft. of surface. From this it will be seen that the number of sq. ft. of rack surface required divided by 100 equals the number of racks ; in other words, each rack is sufficient for 100 children, 66 men, or 50 women. If, in place of racks, clothes lines or portable horses are used, the small hospitals allow 5, 7, and 10 cub. ft. for each child, man, and woman respectively, and one-half this amount for larger hospitals. Clothes, after proper wringing, will weigh from 50 to 100 per cent. more than when dry, and sometimes even more, depending upon the goods. In drying, starched clothes require 25 per cent. more than unstarched ones. Having found the number of racks required add 1 ft. (making an allowance of 6 in. at each end) the total will be the length of the room, the height being 10 ft. and the width 8 ft. Approximately, this equals about 100 cub. ft. per rack. The amount of steam radiation required with a proper supply of fresh air equals about 1 sq. ft. to 3 cub. ft. of space, or about 35 sq. ft. per rack. For hot water work allow twice as much surface for like conditions. For fresh air supply allow 2 sq. in. per sq. ft. of steam surface, and half this amount per sq. ft. of hot water surface. For exit opening allow 50 per cent. more, and if the floor of the room is perforated with small holes for the inlet of fresh air, the above inlet areas should be doubled to allow for friction. An approximate weight per yard of clothes after wringing is about as follows : Flannel skirts, 1 lb. ; spreads, 1 lb. ; sheets, ·6 of a lb. ; blankets, 1·125 lb. each ; shirts, about 1½ lb. each ; pillow cases, about ½ lb. ; and each towel about ½ lb. The weight of the water remaining in clothes after wringing is about as follows, the weight when dry being 1 : Flannel, 2½ ; calico, 1·8 ; silk, 1·50 ; and linen, 1·2 lb. Under ordinary conditions the atmosphere is about 50 per cent. saturated, so that the amount of moisture that a cub. ft. of air will take up, providing that it is saturated on leaving the drying room, is equal to the grains of vapour per cub. ft. for the temperature to which the air is heated, as per previous table, minus one-half the weight in grains contained in the air at its entrance temperature.

Example.—Allow that the air enters at 60° and is half saturated, and that it is heated to 130° F and is saturated on being released. Saturated air at 60° contains 5·82 gr. of vapour, or water, per cub. ft. ; at 130° saturated air contains 42·5 gr. If the air on entering at 60° is 50 per cent. saturated, it will contain 5·82 × ·50 = 2·91 gr. Saturated air at 130° contains 42·5 gr. which, less 2·91 gr., is equal to 39·59 gr. of water that the air will take up in passing through the drying room. If the air was only half saturated on leaving the drying room, it would absorb 42·5 × ·5 = 21·25 − 2·91 = 18·34 gr. of water, removed per cub. ft. of air. If we have to evaporate 100 sq. ft. of water, it will require 100 × 7000 (gr. per lb.) ÷ 39·59 = 17,681 cub. ft. of air heated from 60° to 130°, or 70°, the air on entering being 50 per cent. saturated and fully saturated at exit. Under ordinary conditions 1 sq. ft. of steam heated surface will heat 5 cub. ft. of air 100° to 130° per minute, depending upon the temperature of the air at inlet; in practice it is safe to work on this basis for all ordinary drying work. Allowing that the above quantity of water is to be evaporated in 20 min., the sq. ft. of heating surface required

$$\frac{17681}{5 \times 20} = 176{\cdot}81 \text{ sq. ft.}$$

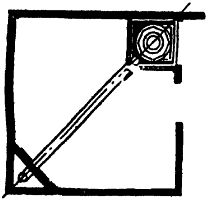

FIG. 190.

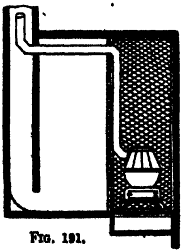

FIG. 191.

The height of a drying room chimney should equal at least four times the height of the room, or, for a standard room, about 40 ft. The velocity of the air in the chimney will average about 300 ft. per min. for ordinary conditions, and it will invariably be found safe to base the area on this velocity and by the following formula—

$$\text{Area sq. ft.} = \frac{\text{Cub. ft. per min.}}{300}$$

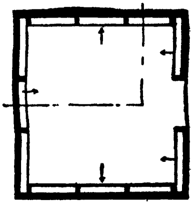

FIG. 192.

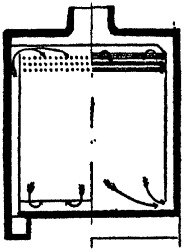

FIG. 193.

The area of flue required to move 17,681 cub. ft. in 20 min. is 424 sq. in., or an 18 by 24 in. flue (17,681 ÷ 20 = 884 cub. ft. per min.; 884 ÷ 300 = 2·95 sq. ft. or about 424 sq. in.). Another important consideration in the construction of a drying room is to secure clean fresh air. This can generally be accomplished by screening the cold air supply through cotton cloth. As a rule it should be taken from the northwestern side of the building. The accompanying figures show several arrangements of drying rooms, with and without portable or sliding horses. Figs. 190 and 191 show plan and elevation respectively from a drying room particularly adapted to private houses, inasmuch as the flat-iron stove heats the drying rooms and produces the circulation of air. As shown by Fig. 190, in one corner of the room is placed a stove used for heating irons, being inclosed by wire netting generally 1½-in. mesh mounted on channel iron frames, the inclosure being entered by a door of similar construction in the laundry. The stove rests on a cast-iron grating opening direct into a cold air box. The flue for the stove is carried into a chimney in a corner of the drying room, diagonally opposite the stove the entrance into the chimney for the exit of air being at the floor. The flue in the vent chimney has a tendency to produce draft. The iron grating around the stove should be extended from floor to ceiling, thus preventing any clothes from coming in contact with the stove. Oftentimes better results will be obtained if the door between the laundry and stove is of wood tinned on inside, in place of a grating; this keeps all the heat in the drying room. Figs. 192 and 193 show plan and elevation respectively

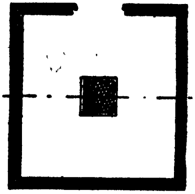

FIG. 194.

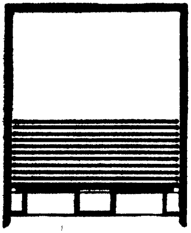

FIG. 195.

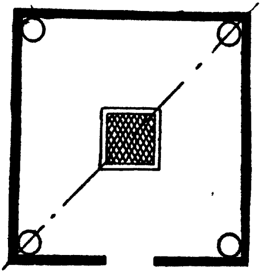

FIG. 196.

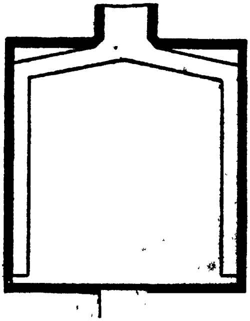

FIG. 19

of a drying room heated by a wall coil, the cold air being taken in under the coil and discharged through a vent register in the floor at the centre of the room. It may be well to state here that large headers are generally made of 3-in. double extra heavy iron pipe, generally drilled and tapped 2¼ in. on centres for inch pipe. Fig. 194 shows plan and Fig. 195 elevation in two sections of a drying room with coil overhead, the cold air supply brought from floor up to ceiling and entering room above steam coil, the air passing downward through the coil, with exit at the floor. Figs. 196 and 197 are respectively a plan and elevation of a drying room, with hot air register in floor at centre of room,

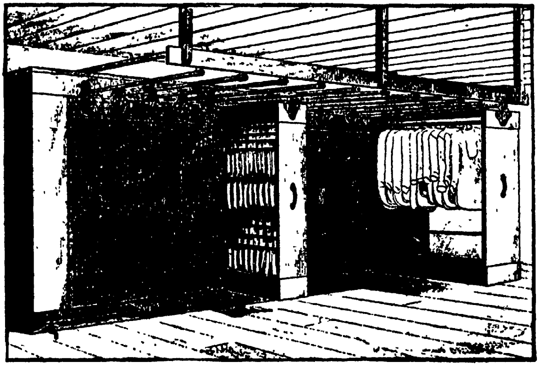

FIG. 198.

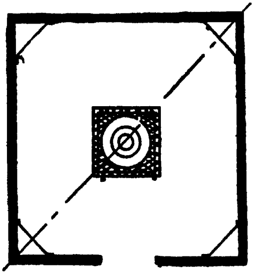

FIG. 199.

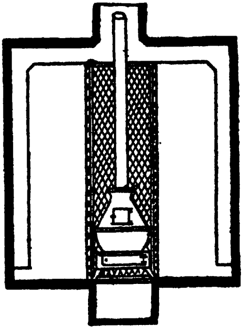

FIG. 200.

the heat being supplied by a stove, furnace, steam coils, or other system below the room; the vent for this room is through galvanised iron pipes, one in each corner terminating in a ceiling ventilation at centre of room.

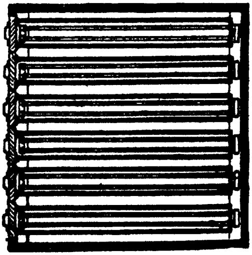
Fig. 201

Fig. 198 is a general view of a drying room showing sliding horses. Figs. 199 and 200 are plan and elevation respectively of a drying room with stove in centre resting on a cast iron grating opening into the cold air duct.

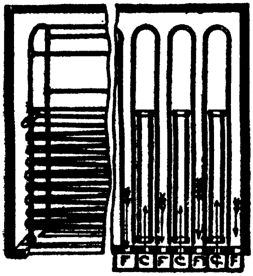

Fig. 202.

The stove should be inclosed by wire guards. The flue for it should be carried up through ceiling and into the vent flue. Vent flues can be formed in each corner with galvanised sheet iron as per sketch, Fig. 200, the flues being connected to the ventilator into which the smoke pipe enters.

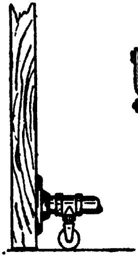
Fig. 203.

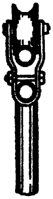
Fig. 204.

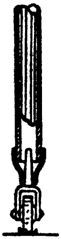
Fig. 205.

Fig. 201 shows plan and Fig. 202 elevation in two sections of a drying room in which the scheme, while expensive to construct, utilises the radiant heat to the greatest advantage and generates a circulation of air in all parts of the room. Figs. 203, 204, 205, and 206 show some details of construction.

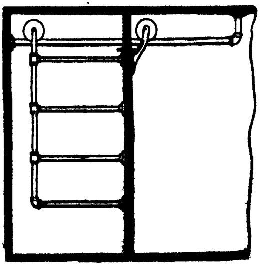
Fig. 206.

Figs. 207 and 208 are respectively broken plan and elevation of a drying room heated by a furnace placed on the same floor, the smoke pipe being carried into the vent flue. If desired, the air can be made to rotate around, but good results are not always obtained in this case. Portable, sliding horses or clothes lines can be used for hanging the clothes on while drying. (Heating and Ventilation.)

Chemists' Hot Air Bath or Closet.—The theory of a perfect method for air-drying suggested two things as indispensable.

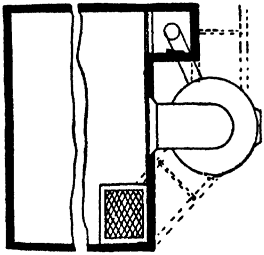

FIG. 207.

1. A constant current of pure dry air brought to the desired degree of temperature before admission into the drying chamber.

2. A regulated source of heat.

Both these conditions to be under perfect control.

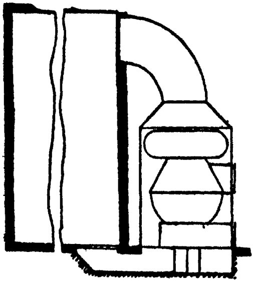

FIG. 208.

I place current first as being the more important item, and the one to which hitherto very little attention appears to have been paid so far, at all events, as regards the temperature of the current when admitted into the drying chamber. As for the source of heat, this has been brought fairly under control by previous experimenters by the use of one or other of the several thermostats, though I was unable to discover one quite suited to the purpose.

To meet these requirements I have designed the instrument shown in Fig. 209. It consists essentially of a double jacketed cylinder with air passages, so contrived as to compel the air used for the drying to circulate between the jackets before its final admission into the drying chamber, in such a manner as to ensure that its temperature shall be raised to the required degree before it is allowed to come in contact with the thing to be dried. Moreover, as a secondary, but still very important consideration, the inlet of the air supply is so placed that the air used for drying is kept as distinct as possible from all contact or admixture with the products of combustion, such products naturally being loaded with watery vapour and CO_2. The pure air thus heated before entering the drying chamber is evenly diffused over the whole area of the bottom of the bath, between it and the perforated false bottom which forms the floor of the drying chamber; the air then ascends bodily as a solid cylinder, and escapes by the tall chimney of the domed glass cover. In this way vigorous circulation of dry hot air is constantly maintained which effects a rapid and uniform drying, such as no ordinary air-bath can accomplish. We will now turn to a consideration of the source of heat and its regulation. This consists of a Bunsen air-burner placed in the cavity under the bottom, but the heat is first received upon a solid disc of metal, separated by a sufficient space from the bottom to prevent the heat of the flame being transmitted direct to the bottom of the bath, the object being to avoid any localisation of the heat. Moreover, the mass of the metal disc besides acting as a distributor, also serves as a reservoir of heat and assists in maintaining the equality of temperature, but this equality is chiefly provided for by an entirely new form of thermostat. It is to be observed that within the two jackets already spoken of is placed an annular copper vessel, which forms the boundary wall of the drying chamber. This is a cylinder composed of two thicknesses of thin sheet copper, enclosing an air-space of 5 mm. wide, 98 cm. circuit, and 22·75 cm. in height. It is securely closed top and bottom, and has a capacity of 1100 c.c. This constitutes the heat regulating chamber or thermostat, the cavity of which is connected up to a U tube, having mercury in the bend. Gas is admitted on the other side of the U, and by means of an arrangement, such as is usual in a gas thermostat, depression of the mercury in one limb cuts off the main gas supply, which can then reach the burner by a small bye-pass only. By means of a screw at the top of the other limb of the U, air can be admitted into or allowed to escape from the regulator. With the rise or fall of the temperature, and the consequent expansion or contraction of the air contained in the regulator, pressure is exerted or withdrawn from the surface of the mercury, which is thereby forced down the one limb and up the other.

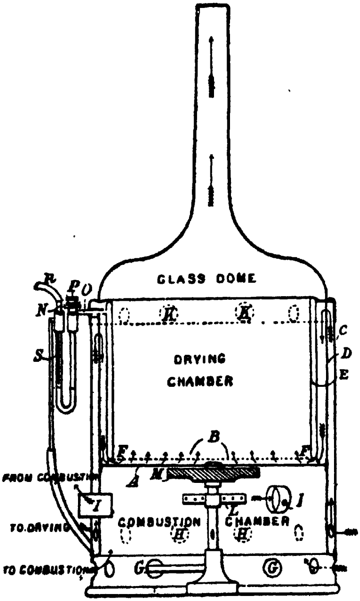

Fig. 209.

The reference letters indicate as follows : A, Diaphragm completely separating the drying from the combustion chamber. B, Perforated false bottom. C, Outer jacket. D, Inner jacket. E, Copper regulating chamber or thermostat. F, Baffle plate. G, Apertures in jacket C giving admission to air for combustion. H, Apertures for the passage of air between the jackets for drying. I, One of three apertures for escape of products of combustion. K, Apertures in inner jacket D for passage of drying air. L, Burner. M, Thick metal plate for receiving heat of the flame. N, Mercury U tube. O, And its connection with copper regulator. P, Screw whereby the degree of heat is regulated. R, Gas supply. S, Tube with bye-pass.

I have already mentioned the capacity of this copper regulator is 1100 c.c., the coefficient of expansion for one degree Centigrade being ·00367, the alteration of volume for a single degree of temperature at boiling point will be about 3 cubic centimetres (2·95). It is therefore plain we have here a means of regulation of the temperature of extraordinary sensitiveness, and accordingly we find we can command what practically amounts to a fixed temperature at any desired degree, and seeing that the copper regulator entirely surrounds the drying chamber and that the whole of the air employed in the drying process must of necessity sweep both its surfaces, exterior and interior, amounting to nearly half a (·4459) square metre in extent, it follows that no local currents can interfere with the accuracy of its workings. You will agree, I am sure, that this is a grand point.

A Page's regulator, or any similar instrument, may be all very well in a still atmosphere, but where a current is concerned it is not unlikely to be at fault and thrown out of working from one cause or another, purely local, such for instance as being shadowed by an object in process of drying, or being placed where there is either an undue amount of current, or too little, or in an eddy. Our arrangement has a further advantage of occupying no space within the drying chamber. Having said this much respecting the principles involved in the design and the mode of construction, let us now pass to a consideration of its performances; but before doing this it will be as well to relate some particulars concerning difficulties encountered in connection with the regulator. When first set in action there was no getting a fixed degree of heat; the thermometer kept steadily mounting, degree by degree without apparent cause. Naturally we looked for some escape of air from the chamber of the regulator, but the closest inspection failed to reveal any point at which escape could take place, and it was only by immersing the copper regulator in water and blowing through the tube attached that enabled us to discover several tiny leaks in the solder. After these were made good and the test repeated, the thermometer still recorded a constantly increasing temperature. Again and again we went through the process of searching for leaks, but all in vain. Fixity of temperature seemed impossible, when at last I observed some condensation of moisture within the U tube on the regulator side of the mercury. This at once gave the clue to the cause of the rise of temperature. Each time of immersing the regulator in the water, when search was being made for leaks, a small amount of moisture must have gained access into the interior, and this, as the temperature of the bath was raised to boiling point, became converted into steam and mingled with the contained air. So long as this moisture remained at the high temperature of the interior of the regulator, it exerted the vapour tension due to that temperature, but little by little a certain portion found its way into the U tube out of reach of the heat, and thereupon deposited its moisture by condensation on the sides of the tube, producing of course a partial vacuum in the tube and thereby drawing in a fresh supply of hot moist air and steam, so that at last quite a considerable amount collected in the U tube. Now, seeing that 1 c.c. of water at 15·5° C. will produce 1696 c.c. of steam at 100° at ordinary barometric pressure, there is no need to dwell further upon the cause of our difficulty, or the necessity for keeping the interior of the copper regulator quite dry.

Now, with respect to the performance of this instrument as an air-drying bath, I have directed my experiments to the demonstration of three things:—

I. To show the existence of, and determine the amount of, current passing through the bath.

I have attempted to measure the amount of air that passes through the instrument by means of an anemometer, and find that it travels along a chimney whose sectional area = 5·4119 in. at the rate of 204 ft. per minute, from which I calculate that no less than 7·6875 cub. ft. of air pass through the apparatus per minute.

II. The next point of importance was to ascertain that this current was evenly distributed throughout the whole sectional area of the drying chamber.

This equal distribution you will observe was arrived at by making the instrument circular and admitting the air at points placed at equal intervals all round, and by surrounding the lower part of the inner jacket with a curved flange projecting inwards, the object of which is to direct the current horizontally between the true and the false bottom, and so prevent its premature passage through the perforations of the false bottom before having had time to take up heat from the bottom plate, and by thorough mingling and mixing, preventing local inequalities of temperature.

That these designs work well can be demonstrated by the smoke of smouldering brown paper, which shows that the current spreads itself over the whole area; there is no creeping up the sides or centre, it seems to pervade equally the whole space.

III. The final point that we have thought it important to inquire into relates to the vertical distribution of the heat.

For the convenience, if not the necessity, of the case, the source of heat is applied to the bottom, and you will remember we have interposed a large mass of metal between the flame and the bottom for the purpose of moderating, storing, and distributing the heat; but, nevertheless, all parts in metallic connection therewith get hot by conduction more in proportion as they are near to the source of heat. They in turn become radiators, and any object placed within near range of their radiation before the air current has had time to take up and distribute the same, gets more than its share of heat. Our experiments show that the useful range is anywhere above 3 in. of the bottom. Below this undoubtedly the temperature increases rapidly, and more so the closer the bottom is approached. About 3 in., and for the whole of the rest of the drying chamber, the extent of the variation between any two parts does not amount to more than from 1° Centigrade.

As regards regulation of temperature, this is as simple as possible. It can be set at any temperature wished for, from that of the room up to any degree that can be required, in the course of a few minutes. I have only to undo the screw P and allow a little of the air contained in the copper chamber to escape, and when the desired temperature is reached, screw it down again; this, by preventing further escape, fixes the temperature at that point. On the other hand, if I want to lower the temperature, I should turn the gas out and allow air to enter the copper chamber until the temperature stands at the desired point. A thermometer hangs from the chimney, and the temperature can be seen at any moment. The regulation can be accomplished not only exactly but immediately, and moreover, the temperature is absolutely fixed. It may be set going on January 1st and go on to December 31st, and it will not vary. It may do some good to put some asbestos on the upper surface of the diaphragm that divides the drying and combustion chambers. (M. A. Adams, F.R.C.S.)

Drying Fruit and Vegetable Products.—(*a*) In numbers of districts in the southern states of North America, one may see at the farmsteads rows of boards tilted up to the sun and covered with sliced fruit. Sometimes it is spread between sheets of muslin to keep away the insects, and to give the fruit a finer colour. These small lots of fruit are collected by the country storekeepers, and thus find their way to the great cities and a market. The first improvement made in drying fruit was tried in the north, and consisted in covering the fruit with glass. The hot-bed sash idle in the barn found a new duty. Wooden boxes or frames made to fit the sash were prepared and set upon legs to raise them above ground. Holes were cut at the front near the bottom, and at the back near the top, to secure a current of air through the frame; within these glass-roofed frames the fruit was spread on trays in the full sunlight. The glass kept out rain, birds, and insects, and the fruit dried more quickly and with less labour than in the old way, and with a decided improvement in its appearance. Experiments were also made with stoves. The cooking stove dried the fruit more quickly than the sun, but it was wanted for other purposes. The next step was to erect drying closets. A small enclosed place or closet of any convenient shape or size was put up in the farmhouse or shed, and in this was set a small stove. The sides of the closet were protected from the fire by brickwork, and above the stove were ranged shelves for the fruit; inlets for the fresh air were made at the bottom, and at the top ventilators were provided for the escape of the heated air and vapour. Such appliances answered a very good purpose, and are often used to save the surplus fruit of a small farm for domestic use or for sale. Besides these domestic appliances there is now in use a very good iron stove or drying machine, serving to dry all kinds of fruit in a better manner than the wooden closets, which are liable to take fire. This stove is portable and may be used out of doors or in a building, as is most convenient. A fire is kept up in the fire-box at the base, and above it are movable shelves for apples, peaches, berries, corn, grapes, or other fruits or vegetables. A constant stream of hot air passes through the apparatus, sweeping across the trays of fruit and quickly extracting all their moisture. The smoke-flue from the fire passes through the escape for the hot air, and materially assists the movement of the air. Driers of this form are largely used in the peach districts of the east and the grape-growing country of the Pacific coasts. They are easily managed, and will dry as much fruit in a day as a family can peel and slice in that time.

At one American establishment apples are pared, cored, and sliced at once by hand machinery. The slices are then spread on galvanised screens and placed in the evaporator, a chamber running from the top of a large furnace in the basement upward, out through the roof of a 3-story building. The current of heated air is kept as near as possible to 240° F. (116° C.). The screens of fruit rest on endless chains that move upwards at intervals of 3 to 5 minutes, when a fresh screen is put in below and one is taken off at the third story completed. The dried or evaporated produce is then packed in pasteboard boxes holding 1–5 lb., and these in turn are packed in cases of 200 lb. each.

A bushel of apples makes about 5 lb. of the dried fruit; and the process of evaporation is so rapid that the fruit loses none of its freshness and flavour. In some of the factories the cores and peelings are converted into vinegar; in others into apple jelly, out of which every variety of fruit jelly is made by the addition of flavouring extracts. Sweet corn, potatoes, and other vegetables have been successfully preserved by this process.

In properly evaporated fruit there is no loss of pleasant or valuable properties, but an actual increase of fruit sugar, from the fact that evaporation is essentially a ripening process, the development of sugar ranging from 10 to 25 per cent. in different fruits, as determined by chemical analysis. By the process of evaporation, properly conducted, in a few hours the juices are quickly matured, the maximum development of sugar is secured, and water pure and simple is evaporated, the change being analogous to the transition of the grape to the sweeter raisin, or the acid green apple to ripeness, with corresponding delicacy. The cell structure remains unbroken, and the articles, when placed in the rejuvenating bath of fresh water, return to their original form, colour, and consistency.

In evaporating cut fruits, such as apples, pears, and peaches, the correct method is to subject them to currents of dry heated air, so as to dry the cut surfaces quickly, preventing discoloration, forming an artificial skin or covering, and hermetically sealing the cells containing acid and starch, which yield glucose or fruit sugar. This principle is demonstrated in Nature's laboratory, in the curing of the raisin, fig, and date, which are dried in their natural skins—a process not applicable to cut fruits—in a tropical climate, during the rainless season, by natural, dry, hot air, in the sun; though a crude and slow process, the development of glucose or grape sugar is almost perfect.

A practical, economical, and inexpensive fruit drier is made by the American Manufacturing Company. In this evaporator separate currents of dry, heated air, automatically created, pass underneath and diagonally through the trays and then off and over them, carrying the moisture out of the evaporator, without coming in contact with the trays of fruit previously entered, and already in an advanced stage of completion. The greatest heat is concentrated upon each tray when it first enters the machine; and each tray subsequently entered pushes the previous one forward into a lower temperature. This operation is continued throughout, being rendered perfectly practicable by an inclined, divided evaporating trunk.

(*b*) It is stated that about a third of the tea produced on Indian estates is cured in Davidson's so-called "sirocco" drying closets. These are made in 2 forms, one having the fire-place adapted for wood, coal, bamboo, ekur grass, or similar fuel, the other suited only for a smokeless combustible, such as coke or charcoal. In the first-named form the furnace of the air-heater is lined with fireclay tiles, and is so arranged that when, from accidental breakage, any of the tiles require changing, this can be easily done through the fire-door, without having to take down any part of the apparatus. All the other parts of the air-heater are very durable, and not liable to breakage.

An improvement has been applied in the construction of the top of the air-chimney, which has completely obviated the necessity for any rain hood or cover (all of which had a harmful effect on the draught). The base of the air-chimney sits on an annular collar, so constructed that it collects and discharges, wherever required, any water which, on rainy days, may come down the chimney, either from a bad joint where it passes through the tea-house roof, or from condensation of vapour inside the chimney. This water collar is applicable to already existing "siroccos."

The trays are made from a special wood, which, after having carefully tested many qualities, has been selected as being the best suited to stand, without warping or twisting, the very high temperatures to which they are subjected; they are strongly put together, being brass-bound at the 4 corners, and the wooden battens screwed together with bolts and nuts, by which they can, if necessary, be tightened up from time to time.

With the exception of the trays, the closet is entirely constructed of iron, and can be readily put together and worked, even by an inexperienced person. It requires no motive power to create the draught, which is self-acting. When erected, it occupies a floor space of about 5 ft. by 4 ft., and is 10 ft. in height from base to where the air-chimney joins.

This apparatus is capable of drying 20–25 *maunds* (1 *maund* = 80 lb.) of green leaf per day of 10 hours, with 6–8 *maunds* of dry wood, or 2½–3½ *maunds* of coal fuel.

The second form differs only in having a brick-built fire-place.

With either form there should be a wooden platform for the man working it to stand upon, and a table for the trays to be rested on, when the material is being spread upon them. One end of this platform should project underneath the apron tray upon the front of the drying-box, and should nearly touch the side of the air-heater casing. The dimensions of this table and platform should be as follows :—

Table, length, 8 ft. ; width 4 ft. ; height, 6 ft. Platform, length, 8 ft. ; width, 3 ft. 8 in. ; height, 3 ft. 6 in. Stair to platform, with two steps, length, 8 ft. ; width of each step, 1 ft. ; height, of each step, 1 ft. 2 in.

Of course the apparatus might be sunk into the ground sufficiently to avoid having to use a platform at all ; but in that case an open space of at least 1 ft. in width would have to be left on each side for admitting the cold air to the air-heater, and a stokehole opposite the fire would be necessary, as well as a similar place on the other side to get at the door for cleaning the chimney. A large excavation like this, however, is obstructive and generally objectionable in the floor of a tea house, and the makers prefer and recommend instead of it the use of the platform and high table, with the apparatus set on ground level, as hereinafter described. Should the apparatus be sunk into the ground, the sides of the excavation will require walls to prevent the earth from falling in ; but if it be placed upon the ground level, no brickwork will be required.

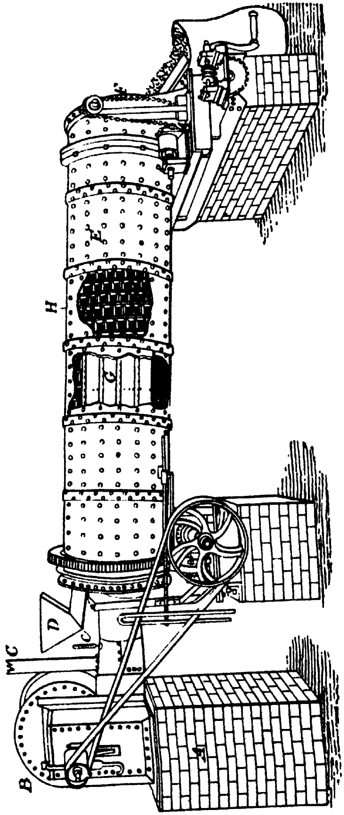

FIG. 210.

It has occasionally been observed that the working of driers is more or less influenced by their situation in the tea house, and that it is desirable, when practicable, to have the apparatus placed on the opposite side of the house to the prevailing winds—i.e. as the winds prevail from S.W. it is well to have the driers situated on the N.E. side of the tea house, otherwise there may be a tendency to a down draught upon the chimney, which would materially affect the outturn of work ; whereas, if placed on the opposite side, the tendency is just reversed, and the draught up through the apparatus is increased by the wind pressure.

Air-holes should always be kept open on the wind side of the house to admit the outer air freely, because each drier (when properly working) is continuously drawing away about 30,000 cub. ft. of air per hour from the house, and if the apparatus has to overcome any friction of resistance in obtaining this air supply, outturn of work will be proportionally reduced.

It may be here stated as a general rule that (provided the proper working temperature of the drier is maintained) the better the draught of the apparatus, the larger will be the outturn of work; and, consequently, everything which tends to accelerate this draught should be observed and taken advantage of.

(*c*) In Fig. 210 is shown an excellent apparatus for drying grain, tea, and every kind of agricultural product. The reference letters indicate as follows: A, Brick box in which coke is burnt, or a flue to convey waste heat from any furnace. B, Compound wrought-iron fan, which will draw waste heat from a distance of 50–100 ft. C, Chimney and valve, to carry off smoke when fire is first lighted. *c*, Thermometer or Pyrometer. D, Feed-hopper, into which the grain is conveyed by an elevator from below, or by a shute from an upper floor. E, Cylinder; when of 18 ft. and upwards, can be made in two lengths, joined in the centre by flanged rings. F, Elevating gear for raising and depressing cylinder. G, Air-duct made of different sections to suit different products. H, Part of the outer shell removed to show the cells in which the grain is carried up and poured out in a continual stream; the number and pitch of these cells are also varied for various products.

(*d*) The cool air drying machine which we are about to describe, is based upon the principle of drying the air before it in turn is used to dry the material to be operated on; and this drying of the air itself is performed by bringing it into contact with a system of iron tubes heated in a furnace to about 1300° F., when part of the aqueous vapour is dissociated into oxygen and hydrogen. The oxygen attacks the surface of the iron tubes or other pieces of iron, such as nails and filings, placed there for the purpose, and the hydrogen passes away with the rest of the air. If, now, this mixture of dry air, with a small percentage of hydrogen, be cooled again to the original temperature, it will be capable of taking as much moisture as it originally contained. Power is supplied by a Robey undertype steam engine, which works two fans placed under a wooden box, and a number of vertical agitators placed in the drying chamber between the stacks. The air from the fans is forced through a series of vertical tubes placed in a box technically termed the "cooler." After passing the tubes, it is forced through another series of tubes placed in the "furnace," and is there heated to about 1300° F. After passing through the furnace tubes, the air is conducted back to the cooler; but this time it surrounds the outside of the vertical tubes and flows finally to horizontal flues placed on the ground, which lead into the drying chamber. The air, on coming from the furnace, is cooled by contact with the outside of the tubes, through which fresh air is pushed into the furnace; and the cooler in this manner performs two functions, viz. it heats the air on its way to the furnace, and it cools the air after it has left the furnace. The machine is provided with a second cooler, technically termed the "water cooler;" but this is an addition made merely for the purpose of experimenting. The water cooler is arranged somewhat in the manner of an ordinary surface condenser of a steam engine, with the only difference that, instead of exhaust steam, the air coming from the air cooler is passed through it. This water cooler can be filled more or less with water, and the water can be renewed at a faster or slower rate. By this means, its cooling effect upon the stream of air can be varied so as to obtain the dry air finally at any desired temperature between 150° F. (the temperature to which the air cooler reduces it) and 60° F., or even less if desired. The water cooler is never used in drying machines when not required for experimental purposes; for actual practical work an air cooler alone is used, and its size is so chosen as to reduce the temperature of the air to the desired degree. The goods to be dried are stacked on trolleys and run into the compartment, care being taken to put the heaviest stuff first, because it requires a longer time to get dry. The agitators are worked from bevel gear overhead, and are placed over the main flues by which the dry air is conveyed to the drying chamber. A hole about 10 in. diam. is cut in the top of the flue below each of the agitators, and the air streaming up through this hole is scattered about by the fans of the agitators, so as to penetrate the interstices left between the stacked goods. In this way the whole of the surface is evenly surrounded by a gentle stream of dry and comparatively cool air. The air, as it passes through the stack, becomes charged with moisture, and if it were not quickly removed, it would impede the further process of drying. To facilitate its removal, exhaust fans are arranged to draw the air through the hollow lining of the walls of the drying chamber, and discharge it into the atmosphere. The whole air contents of the drying chamber, when full, are changed every two minutes. At the time of our visit, we saw in the drying chamber mahogany boards 2¼ in.–3¾ in. thick, oak flooring, also some walnut gun stocks, a large pile of billiard cues, and a big parcel of pine deals 12 ft. by 9 in. by 3 in. The best proof that the drying of the wood is effected without warping lies in the fact that billiard cues can be successfully treated. Boards 1 in. thick require to be left in the drying chamber for about a fortnight, 2-in. stuff would be left in a month, and so on in proportion to the thickness for heavier stuff. We may take it that to stack mahogany boards in the open air in order to season the wood in the old way, would cost about 6*s.* a square, that is, inclusive of ground rent, fire insurance, and interest on the capital lying idle. The timber will in that case take about twelve months to become seasoned. If artificially dried, the process will be completed in a fortnight at a somewhat smaller charge than 6*s.* per square. Thus the artificial method is not only cheaper, but it has the great advantage of enabling the money to be turned over quickly, instead of lying idle in stacks. ('Industries.')

Mechanical Methods. — Foremost among mechanical appliances for this purpose ranks the centrifugal machine, or hydro extractor. In principle this apparatus consists of an upright drum, which can be made to revolve with great velocity on a vertical axle. The drum may have its sides constructed of sheet metal, perforated with a multitude of fine holes, of wire gauze properly supported, or of basket work according to the nature of the substances to be treated. The drum, being charged with material, is set in quick rotation. The water present is thus expelled through the perforated sides in the form of a fine shower. This process is exceedingly well adapted for removing the greater part of the moisture from cloth, yarn, unspun wool, etc.; also from crystalline and granular substances. It is not so well adapted for drying wet powders, pastes, etc., since in such cases a very considerable proportion of the solid matter is projected away along with the liquid, so the holes may get choked up. Thus it has not hitherto been found satisfactory for drying sewage mud. Its use requires, further, special modifications where the liquid to be got rid of is not pure water, but holds useful, or hurtful, matters in solution. A recent very simple improvement has considerably extended the use of the hydro extractor. The materials, instead of being put into the drum loose, are inclosed in bags of some suitable material, thus preventing the dispersion of the solids. This method has been very sucessfully adopted with butter. It must, however, be remembered that no substance, especially if of organic nature, can be rendered absolutely dry by the use of the hydro extractor.

Another mechanical agency for desiccation is the press, more especially that device known as the filter press, which has proved itself invaluable for separating solids from fluids when the latter largely predominate. This apparatus contains a number of cells, each consisting of a couple of cast iron plates lined, when in use, with suitable cloths. The inner surface of each plate shows a number of ridges. The liquid paste is forced by a pump, or press, into each cell through an aperture, and the water escapes through the cloth, and trickles down between the grooves formed of the ridges to the pipe at the bottom.

The filter press, like the centrifugal machine, only expels a part of the water in mud, etc. ; thus, if a sewage mud contains at the outset 90–95 per cent. of moisture, it may be reduced by the filter press down to 50–60 per cent., according to the time during which the pressure is maintained. It is only in a few cases that hydraulic presses, screw presses, etc., can be employed for desiccation.

Small Hot-Air Baths or Closets for Laboratory and other purposes.—(*a*) The ordinary steam or hot-air chambers for laboratory use, although meeting the most of the requirements for which they are designed, having the disadvantage of being more adapted for experimental than manufacturing purposes. The want of a cheap and convenient apparatus induced Maben to bring under notice a design (Fig. 211) due to Hislop, one of his apprentices, who intended it for drying photographic gelatine plates ; but, by slight modifications of the interior, it is perfectly adapted for the purposes of the laboratory.

The chamber consists of a strong wooden box *a*, 18 in. high by 18 in. wide, and 14 in. deep. To the front a door is attached, hinged in this instance, but a vertical sliding movement would be more convenient. To 2 sides of the box are fixed wooden supports, which serve to receive teak spars for supporting drying trays or evaporating dishes. The bottom of the box has a perforation of 3 in. diameter into which a zinc cylinder *b* is securely fitted, and to this is soldered the upper end of a copper cone *c* with a flat bottom, while into this latter a bent tube *d* 2½ in. diameter, and 9 in. total length, is securely inserted in the manner shown. A corresponding perforation is made in the top for receiving a tube to answer the purposes of a chimney.

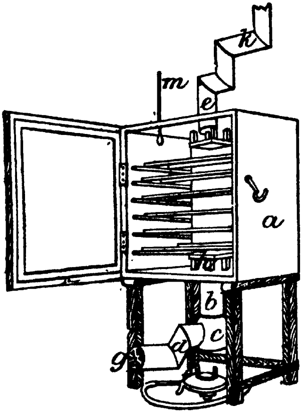

FIG. 211.

Using a Bunsen burner or a spirit lamp as the source of heat, the flame is directed to the bottom of the cone *c* with the result that the heated air ascends into the chamber, being diffused by means of a dispersion board *h* about 4 in. square, which is placed over the orifice. At the end of the tube *d* is fitted a "hit-and-miss" regulator *g*, which consists of a series of triangle-shaped holes, with a revolving disc behind, so that the size of the apertures can be increased or diminished, thus enabling the amount of air entering to be under partial control. The highest temperature to which the air in the chamber has been raised is 180° F. (82° C.) which is sufficiently high for most operations. If a uniform temperature of say 100° F. (38° C.) be required, the admission of air must be regulated accordingly by means of the regulator *g*, accuracy being insured by the insertion of a thermometer *m* into a perforated cork fitted into a ½-in. aperture on the top of the chamber. By this means there is no difficulty in keeping within 2½° less or more of the desired temperature.

If a rapid current of warm air is desired, this can be had by placing an angular tube *k* on the top of the chimney *e*; by heating the angle of the tube, a draught is quickly created.

It is desirable in some cases to filter the admitted air; this can be done by stretching a piece of lint or other suitable material between the regulator *g* and the tube *d*, by which means dust particles are effectually excluded.

The metallic parts of the apparatus being made to screw off and on, they can be detached at will, so that we can thus have a series of wooden chambers suited to different purposes. In this instance, the chamber being intended for drying gelatine plates, it was of course constructed so that the light would be effectually shut out, but it is obvious that a small glass window would add greatly to its value for most other purposes. The advantages of this chamber are its simplicity, its perfect security against overheating, and its small cost—it can be made for a few shillings. It is light and easily handled and is always ready for work, a current of pure hot air being obtained in a very few minutes after the application of the Bunsen flame. It is specially adaptable in the preparation of granular and scale compounds, for drying precipitates, hardening pills previous to coating, and in other operations requiring a current of hot air.

(*b*) A writer describes his drying-closet as being made of teak 1 in. thick, with light-tight door in front; the ends project beyond the bottom to form legs; the top and bottom are both double (4 in. apart), and the air enters through a slit 3 in. wide, and reaching right across the box. This slit is at one end, and the air has then to pass along the double bottom to the other end, where it gets into the box through a similar slit, thus keeping out the light; and it gets out at top in a similar way. Over the exit at top is fitted a tin or copper chimney 3 ft. high, in which burns a Silber lamp, giving a good draught, and drawing a large quantity of air through. Inside the box are brackets (each having a levelling screw through it, with the point upwards), projecting from the ends, on which are laid plate-glass shelves cut the width of the box, but 3 in. shorter, so that when the shelves are in place, if one is pushed close to the right end of the box and the next to the left, and so on, the air has to pass backwards and forwards over the plates. His box has 3 shelves, 13 in. wide and 32 in. long, and will dry 6 photographic plates 15 in. by 12 in., or, of course, anything less that will lie in the same space. Some have an arrangement for drying and warming the air before it enters the box; but this sometimes induces blisters and frilling. Shelves should be far enough apart to get the hand in easily, say 6 in.

(*c*) Fig. 212 shows a sectional view of another form of photographic drying-box. *a* are shelves on which to put plates. In the drawer *b* are placed some lumps of calcium chloride. This absorbs moisture very rapidly, and the air in passing through it is thoroughly dried. In the flue *d* is a small gas-burner, and below is a light trap *c*, made of tin. The gas-jet is for the purpose of causing an extra current of air to pass over the plates. It is better to confine the plates as much as possible to the 2 middle shelves, as there they are sure to be safe. At *c*

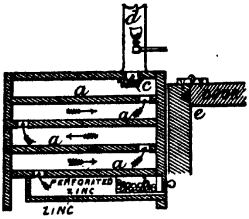

FIG. 212.

is a sketch showing how the door of the box should be rebated into the side.

(*d*) England's drying closet, Fig. 213 is simply a light-proof box with wires

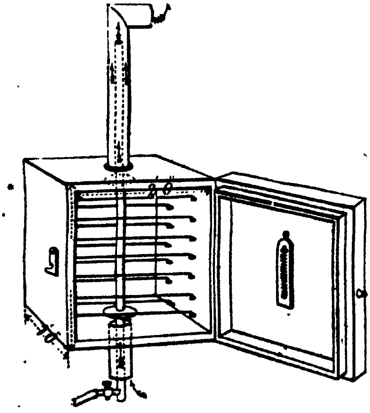

FIG. 213.

stretched across the interior to support the articles to be dried, e.g. photographic plates. Through the centre runs a 1-in. gas-pipe, open at both ends, with a small gas-jet burning inside it at the lower end. At the top and bottom of the box 2 draught holes are cut, to which a tin tubing of about 3 in. diameter is attached. The gas-tube gets warmed with a very small jet of gas burning in it, a mere pin-hole being sufficient exit for the gas. This warms the air in contact with the tin tube, and also slightly the air inside the cupboard. The consequence is, that a current of slightly warm air is set up, and circulates amongst the plates while supported on the wires, and the drying of the films takes place rapidly. Some 5–6 hours is a sufficient time in which to dry the plates, whilst without the gas-jet it would take 24 hours or more. In the inside of the cupboard, and near the top and bottom, are placed 2 cardboard discs to stop the possibility of any stray light entering, and as the whole affair is placed in the dark room, the chances of any such access even without it would be small. Inside the cupboard door is a thermometer, and the jet is regulated so that a temperature of about 70° F. is indicated—80° would do no harm to the plates; beyond that temperature, it might not be safe to go. The small gas-jet used is the same as may be seen in tobacconists' shops; the hole in the end is plugged up, and a very small hole is drilled at the side.

(*e*) A photographer adopted a large zinc case with a lid of the same material. He cut a long opening at one end of the bottom, and had another bottom soldered inside with an opening at the opposite end (Fig. 214). He then had a Russian iron chimney fastened on one of the sides, and fitted this with a gas-flame placed as shown, so that it might produce the necessary current of air. To make the cover fit air- and light-tight was rather more difficult. This, however, he managed in the following manner. He had a rim soldered all round in the shape of a gutter, the edge of the lid sinking into the bottom of the gutter, and then filled the latter with small shot, and thus obtained a most perfect closure. This box has been in use ever since, and, with the addition of a wooden tray, and of an iron vessel full of calcium chloride, has done very good service. In the figure, *a* is the zinc case; *b*, gutter filled with shot; *c*, wooden tray; *d*, calcium chloride vessel; *e*, Russian chimney.

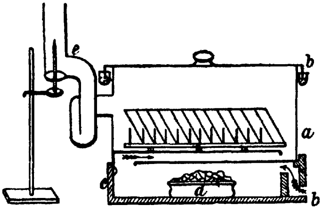

FIG. 214.

(*f*) The usual forms of hot-air baths used in laboratories are, almost without exception, affected by drawbacks, particularly the following:—

1. Either the temperature in the upper and lower parts is different; or
2. The temperature differs with the duration of heating; or
3. It can only be raised to a moderate degree; or
4. Finally, it can be kept up only by a relatively large consumption of gas.

Meyer proposes to remove these defects in the following manner:—

Equality of temperature may be attained by applying the heat at the side—never below—and by taking care that the flame never comes in actual contact with the metal. The space to be heated is to be surrounded, with the hot products of combustion of the flame mixed only with the smallest possible excess of air, in such a manner that a triple layer of heated gases, proceeding from without inward, surrounds the inner mantle. Besides, the outer, or hottest layer, must be protected from too rapid cooling by applying a suitable coating of bad conductibility for heat.

Equality of temperature for any length of time may be best attained by a regulator constructed on the principle of Andrea's, which contains, in a small, confined space a small quantity of a liquid having a boiling-point a trifle below the degree of temperature to be maintained. The author prefers the modified form suggested by Kemp, and improved by Bunsen, which is wholly constructed of glass except the lower end of the gas-tube, this being made of perforated sheet-platinum.

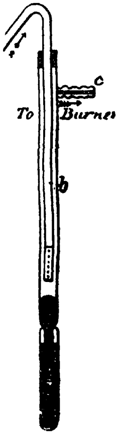

FIG. 215.

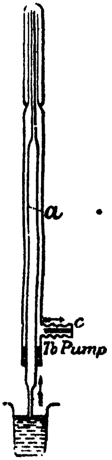

FIG. 216.

In order to fill it, the gas-tube *a*,

Fig. 215, is temporarily replaced by a tube *b* drawn out at both ends and reaching down into the reservoir of the regulator (top of Fig. 216). The lateral branch *c* is now connected with the vacuum pump, the whole inverted, (as in Fig. 216), and the contracted end dipped, first into the liquid to be used as regulator, and then into mercury, until the chamber is almost, but not quite, full. The apparatus is now turned over, a little more mercury poured in, and the gas-tube *c* is inserted. When using the apparatus, the gas-tube is first drawn upwards, and, when the proper temperature has been nearly reached, pushed down into the mercury, until the supply of gas is reduced to a minimum. By cautious adjustment, it is easy to find the position at which the tension of the vapour developed in the tube raises the column of mercury sufficiently to just close the orifice of the tube *c* at the proper temperature. As the air-bath cools off very slowly, but heats up rapidly, it is of advantage to adjust the regulator to a slightly lower temperature than actually required.

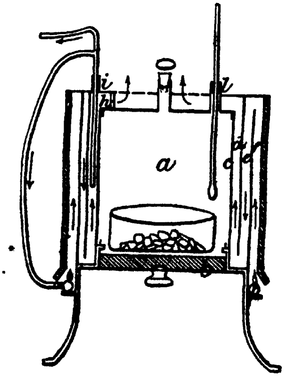

FIG. 217.

It is best to have a series of such regulators, charged with substances, the boiling-points of which are about 30° C. apart, and to keep them in a proper receptacle for use. Suitable substances are, for *water-baths*: ethyl chloride, ether, carbon disulphide, mixtures of ether and alcohol, pure alcohol, benzol; for *air-baths*: water, toluol, xylol or amylic alcohol, cymol or oil of turpentine, aniline or phenol, naphthalin, diphenyl or diphenylmethane, diphenylamine, and perhaps also anthracene. It is not at all necessary to use these in a pure state, particularly those which are solid at ordinary temperature, since they melt more easily when impure. Only very little of solid substances should be introduced, for the excess distils off, and may clog up the gas-tube.

Figs. 217, 218, and 219 show the air-bath as usually employed by the author. It consists of 4 concentric walls of sheet copper, 2 of which are attached to the upper plate, and the others to the bottom plate.

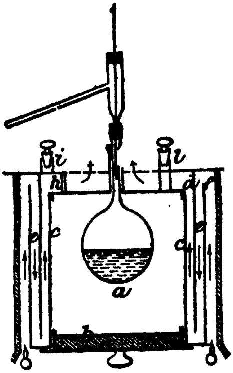

FIG. 218

Fig. 217 is arranged for a drying chamber; Fig. 218 for the distillation of substances which easily decompose when coming in contact with (over) heated glass; Fig. 219 for the dry distillation of substances which should not be heated beyond a certain point (for instance, citric acid in the preparation of aconitic acid, etc.).

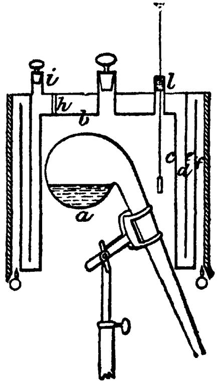

FIG. 219.

The innermost cylinder* surrounds the space *a* to be heated, which is closed from below by a double bottom *b*, fastened by a bayonet-clamp. The upper cover also double (the 2 walls being kept parallel by inner supports, of which one is shown at *h*), has 2 tubulures, one (*l*) for the insertion of a thermometer, another (*i*) for the regulator, and another for the escape of the heated vapours. To this cover the 2 cylinders *d* and *f* are attached while *e* and *c* are soldered to the bottom piece, which is also provided with 3 legs. The heating is done by a brass ring attached to the legs, with a supply of gas controlled by the regulator *i*. The ring has holes of 2–3 mm. bore in intervals of 3 cm. The little flames thus produced burn quietly and may easily be regulated. With the same amount of gas which is furnished by a gas-cock supplying an ordinary Bunsen's burner, the space in *a* (= about 5 litres) may readily be heated to 300° C. and over, even when it is not closed below. But in order to obtain this result, the intervals between the several cylinders, in which the products of combustion circulate, must not exceed 10 mm. Besides, the outer cylinder *f* must be protected with a non-radiating cover. The best, for this purpose, is a layer of asbestos (in sheet), to be applied so as to leave a little space between it and cylinder *f*, which space is to be filled out with silicious earth ("kieselguhr") or mineral wool.

If tubes are to be heated, the modification shown in Fig. 220 may be used. It is also here of importance that the channels through which the warm air circulates are very narrow, scarcely 1cm. apart. The 8 iron tubes pass through the narrow walls, which latter are not double but covered with little flaps hinging upwards (one corresponding to each tube), as closely as possible fitting to the surface of the outer cylinder, but remaining slightly distant from the ends of the tubes. In case a glass tube (inserted in one of the iron tubes, for being heated) should explode, its fragments are caught by the loosely hanging flaps. Between the iron tubes, a Babo's regulator may be inserted.

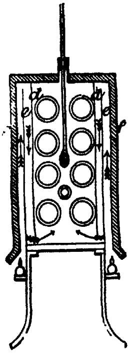

FIG. 220.

For special uses the above forms of air-baths may be still further modified. It is, however, of importance to remember that the heated gases should surround the space to be heated in a triple layer; that the hottest layer should be near the outside, and that the intervals between the walls should admit as little excess of air as possible.

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* The air-chambers illustrated above are not square, but *round*. The illustrations represent a vertical section through the centre.

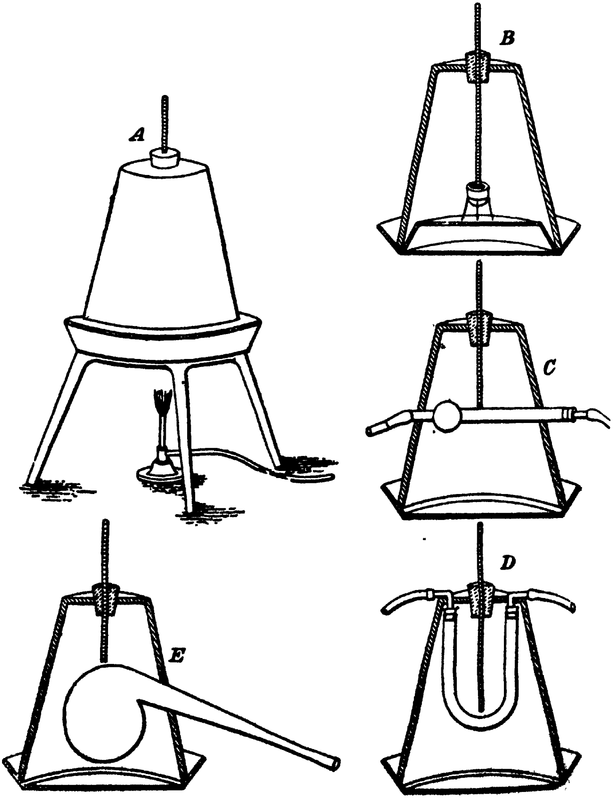

FIG. 221.

The gases escaping above must have the property of extinguishing a glowing splinter of wood.

(*g*) The air-bath ordinarily used in chemical laboratories for drying precipitates, for making determinations of water by loss, and for similar purposes, is usually a rather expensive piece of apparatus. The iron or copper closet, with its door, tubulure for thermometer, shelves, stand, etc., works no more satisfactorily because of its somewhat elaborate or difficult construction. In Fig. 221, is shown a simple substitute for this apparatus, that as regards simplicity cannot well be excelled, while its other good features certainly operate to commend it. It consists of an inverted flower-pot sustained upon an ordinary tin pan or sand bath, the whole being carried by a tripod or retort stand. The aperture at the top serves to receive a perforated cork, through which a thermometer is passed. An ordinary Bunsen burner is used to heat it. As the sand bath directly over the burner becomes very hot, it is advisable to invert a second smaller sand bath within the first, as shown in B. This prevents too direct a radiation of heat from the hot metal. Upon this the little stand or bent triangle supporting the crucible or watch glass containing the substance to be heated may be placed. The thermometer should be thrust down through the cork until its bulb is near the substance to be dried, so as to obtain a correct indication of the temperature at that point. The entire arrangement is shown in external view in A.

To place a vessel in it or to remove one, the flower-pot is lifted off the sand baths. It will be observed that its porous nature provides a species of ventilation, while its composition assures it against corrosion. It even protects the plates below to a considerable extent, as drops of water or other luid cannot run down its sides as it cools.

But convenient as it is in the rôle of air-bath for simple drying operations, it will be found more so where drying tubes or retorts have to be manipulated at constant temperature. The flower-pot can be perforated at any place, and holes of any size or shape can be drilled and cut through it with an old knife, file, or other implement. Thus in C it is shown in use for drying a substance at constant temperature in a straight drying tube. The holes to receive this tube can be drilled in a few minutes. The arrangement as shown is of the simplest kind, but if the usual bath was used, it would require a special tubulation to be introduced or contrived for the tube to pass through. Flower-pots cost so little that there need be no hesitation in preparing them for special uses.

In D a U tube is shown as being heated, while in E a retort occupies the bath, and is in use for fractional distillation or other operation requiring a constant temperature. In all cases it is better to use the second bath inverted within the chamber. It conduces greatly to the maintenance of an even temperature throughout the whole space. A hint may also be taken from the heavy drying plate formerly perhaps more used than at present. If for the light metal pans a heavy plate ½ in. or more in thickness is substituted, the temperature will not be subject to as rapid variations, and less difficulty will be experienced in keeping a constant temperature. The tray furnished with the next large size of pot may be used instead of the sand bath upon which to rest the inverted flower-pot. This gives an absolutely non-corrodible construction.

When the bath is in use for drying substances, its top, which is at a rather low heat, affords an excellent place of drying precipitates wrapt in their filter papers. It acts in two ways. It is generally just hot enough to dry them with reasonable quickness without danger of spurting, and it also acts by capillarity to absorb the water directly It represents in the last respect the porous tile or blotting paper—appliances too little appreciated by chemists here. It must be remembered that the drying of a precipitate by evaporation leaves all the impurities of the wash water concentrated therein, while capillary absorption removes a great part of both wash water and its impurities, thus conducing to the accuracy of the work. (T. O'Conor Sloane, Ph. D

Water-heated Air Baths and Ovens. (*a*) The accompanying sketch (Fig. 222) of a combined steam-oven and distilled water apparatus, so arranged as to be left to itself for a long period of time without the risk of the boiler going dry, may perhaps be of interest to many, and a few words only are necessary to describe its working. The steam oven *a* is of the ordinary construction, but is fitted at the side with a tube connecting it with the condenser *b*. Heat is applied to *a* by means of a radial burner, connected with the gas supply by metallic tubing; the steam generated circulates around the drying chamber, escapes through the copper tube *c*, thence through block-tin worm, and falls as distilled water in the receiver *d*. The cistern *e*, fitted with a Mariotte's tube, holds cold water, which falls through the tube *f*, enters the condenser, where it rises slowly, absorbing heat from the condensing-worm, until it reaches the tube leading to the boiler at a high temperature. For a cistern, an 18-gal. ale cask, supported on a stool, has been found to answer admirably, having the advantage of holding sufficient water on the top to secure the 2 corks being air-tight. By a suitable adjustment of the Mariotte's tube *h*, the rate of flow of the water can be so regulated that the level of water in the condenser is constant, or, if desired, allowed to drop slowly into the waste pipe, while the water evaporated from *a* is renewed by water already near boiling. In practice it has been found necessary to allow the water to waste at the rate of about 2 drops per minute, the 18 gal. lasting for over 72 hours, during which time 10–11 gal. of distilled water are collected. When this apparatus was first fitted up in the laboratory, it was intended to have connected the condenser directly with the town water supply, but as the waterworks authorities would sanction no such connection, we had recourse to the cistern, with the satisfactory result that we are in this respect quite independent of the caprice of the waterworks turncock. The several connections are made by union joints, to allow the apparatus to be taken to pieces and the boiler freed from scale. The whole apparatus may be supported upon a strong shelf, which should be protected from the heat of the burner by means of slates or asbestos millboard. With this arrangement, bulky precipitates may be allowed to remain in the steam-oven all night and found ready for further treatment next morning. ('Chemical News.')

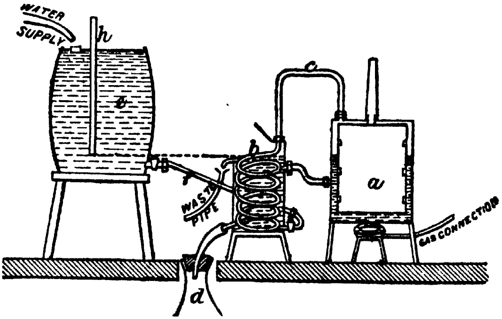

FIG. 222.

(*b*) In Fig. 223 is shown a constant water bath, consisting of a square box A, supported over a Fletcher's solid flame burner. The top of the box, 15 × 15·5 in., is formed by a brass plate, $\frac{1}{8}$ in. thick, which thus is stiff enough to support a considerable weight without yielding, the sides and bottom being sheet copper. From the point, B, projects a $\frac{1}{2}$-in. brass tube, B C, which turns up at a right angle. At E is a stop-cock, which is connected by a thick rubber tube with the glass tube, D F, which is fastened against the adjoining wall. Connected with C by a rubber joint is a $\frac{1}{2}$-in. block tin tube of 20 ft. length, which extends up the wall in the manner shown to the highest point, T, and thence returns and ends just over the slightly funnel-shaped top of the glass tube at D. The bath being filled with water to just the level, B *b*, may be kept constant by boiling for many days without appreciable loss of water, the steam being condensed in its passage up, or, if uncondensed before it reaches the point, T, in its passage down the block tin tube. In flat-bottomed platinum or porcelain capsules, evaporation goes on very rapidly when placed on top of this water-bath. The whole surface of the bath is nickel plated. ('Journal of Analytical Chemistry.')

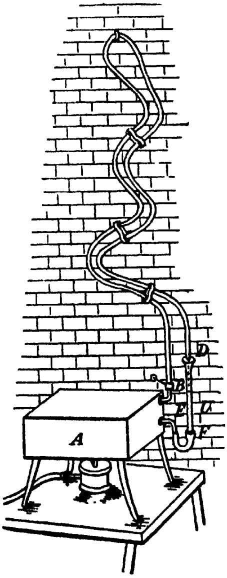

FIG. 223.

Chemical Drying Agent.—Chloride of calcium is cheap (being a waste product), easily portable, and when it has absorbed moisture it can be again made fit for use with no more complicated apparatus than an iron pot. Air dried by means of chloride of calcium has, therefore, very naturally come into use for drying purposes. But it is sometimes employed in an unsatisfactory manner, by a mechanical arrangement. The chloride of calcium is alternately exposed to the current of air to be dried, and is then passed into a furnace, in the expectation that moisture will thus be alternately absorbed and expelled. This view seems to be erroneous. Chloride of calcium parts with two-thirds of its water at 392° F., and loses the remaining third at a higher point. Unless the heat is carried to this point, the chloride of calcium does not recover its original capacity of water. If it has been thus heated, it wants sufficient time to enable it to cool down to a temperature below that at which it parts with its moisture. Chloride of calcium, at temperatures above the boiling-point of water is a comparatively small desiccating agent. There is another method in which chloride of calcium may be applied in desiccation, a method often used in the laboratory. The substance to be dried is placed in a vacuum—or even in a closed receiver, filled with air at the ordinary pressure—along with trays of chloride of calcium. In this manner, the moisture evaporating from the material is at once absorbed, and fresh moisture can be given off to take its place.

Abstracting Water by Cold.—The concentration of saline and saccharine solutions by the abstraction of surplus water is another branch of desiccating. This is usually performed by means of heat, as described under Evaporating, but may be sometimes advantageously effected by the aid of a low temperature. Thus in several countries where severe weather predominates common salt is obtained from the ocean by exposing sea water in shallow reservoirs to the action of the frost. The water becoming frozen separates from the saline bodies which it held in solution, and on being removed in the form of ice the latter can be collected from the bottom of the receptacle; or repeated coatings of ice can be taken from as many freshly admitted supplies of sea-water till the solution reaches a highly concentrated form, needing but little evaporation to form a crystalline product.

Another direction in which the concentration of solutions by cold is successfully applied is in warmer countries where sugar forms one of the agricultural products. Thus in Ohio the native women were accustomed to expose the syrup as collected in shallow pans to the night air, when the cold would suffice to freeze the water and and form a crust of ice over the thereby concentrated syrup below. The bulk of the superfluous water being thus got rid of, very little further concentration by means of fire is needed to produce a solid sugar.

END OF VOLUME I.

INDEX.

A

Acetylene lighting, 1
Acid chambers, cement for, 255
—— drops, 395
—— extracting from sugar, 402
—— standard solutions, 7
Acidimetry, 5
Acid-proof alloys, 50
—— —— cement, 227
Aconitine, 30
Adhesives for labels, 253
Aerating agents, 7
Aggregates for concrete, 382
Aich metal, 50
Air baths, 512
—— —— water heated, 513
—— bubbles, expelling from barometer tubes, 101
—— currents, determining, 81
Alabaster cement, 228
—— cleaning, 293
Albumen, 8
—— bleaching, 129
Albums, repairing, 192
Alcohol, 13
—— barrels, 24
—— denatured, 23
—— distilling, 465
—— rectification, 20
—— testing specific gravity, 25
Alcoholometry, 24
Algerian cements, 228
Algiers metal, 65
Alkali, cleaning stains of, 322
—— determination of, 28
—— standard solutions, 7
Alkalimetry, 28
Alkaloids, 29
Alloys, 41
—— acid proof, 50
—— aluminium, 50
—— aluminium bronze, 51
—— aluminium zinc, 51
—— anti-friction, 52
—— antimony, 53
—— Babbitt's metal, 52, 53
—— bearing brasses, 54
—— bell founding, 112
—— bell metal, 54
—— Birmingham platinum, 76
—— bismuth bronze, 54
—— brass, 55
—— Chinese white copper, 76
—— copper-manganese, 67
Alloys, Delatot's white metal, 69
—— density of, 42
—— Fahlun, 76
—— fluxes for, 44
—— for impressions, 61
—— furnaces for melting, 46
—— fusible, 58
—— fusibility of, 43
—— gong metal, 112
—— gun metal, 60
—— inoxidisable, 60
—— iridio-platinum, 61
—— iron, 61
—— Japanese, 64
—— jewellers', 65
—— journal boxes, 66
—— Karakene, 112
—— kettle brass, 70
—— locomotive bells, 112
—— manganese, 45, 66
—— medals, 69
—— melting, 44
—— miscellaneous, 77, 78
—— Muntz's metal, 69
—— or-molu, 69
—— Parker's, 66
—— peak metal, 70
—— pewter, 69
—— phosphor, 71
—— phosphor bronze, 72
—— pinchbeck, 72
—— pipe metal for organs, 72
—— plate pewter, 69
—— queen's metal, 72
—— railway signal bells, 112
—— resembling silver, 76
—— rivet metal, 72
—— Sauvage's, 66
—— ship bells, 112
—— silver, 73
—— sleigh bells, 112
—— small articles, 73
—— soft, 73
—— solders, 73
—— specific heats of, 44
—— specular, 74
—— stereotype metal, 74
—— sterro-metal, 74
—— strength of, 41
—— table bells, 112
—— tin brilliants, 76
—— tin-manganese, 68
—— tombac, 75
—— tungsten bronzes, 75
—— tutania, 75

Alloys, type metal, 75
—— victor metal, 77
—— white metal, 76
—— zinc bronzes, 77
Almond comfits, 401
—— creams, 391
—— hardbake, 394, 395
—— paste cement, 228
—— rock, 395
Almonds, burnt, 397
—— salted, 393
Alpacas, cleaning, 334
Aluminium alloys, 50
—— bronze, 51
—— paper, 79
—— zinc, 51
Amalgams, 79
—— copper, 80
—— for coating plastic castings, 80
—— gold, 80
—— iron, 80
—— silver, 80
—— sodium, 80
—— tin, 80
—— zinc, 81
Amazon bitters, 117
Amber, 81
—— cement, 228
American cement, 228
—— clock, repairing, 361
Ammonia, cloudy, 451
Ammonium carbonate baking powders, 87
Amorphous quinine, preparing, 37
Anatomical specimens, bleaching, 130
Anderson's heat regulator, 511
Anemometers, 81
—— Biram, 82
—— graduation of, 83
—— Henault's, 84
—— Lind's, 82
—— multiplying, 85
—— simple, 84
Aneroid barometer, 105
Angostura bitters, 117
Aniline colour stains, removing, 319
Animal fibres, bleaching, 129
Anti-friction alloys, 52
Antimony alloys, 53
—— iron alloys, 62
Antique gold alloy, 66
Apples, drying, 503
Aqua fortis, 85
Aqua regia, 86
Aquarium cement, 228
—— repairing leaks, 87
Architectural cement, 229
Argentin, 65
Armenian cement, 230
Aromatic bitters, 117
Arsenic-iron alloy, 61, 63
Artificial gold, 69
—— gum, 247
—— ivory, 223
—— pearl, 222
Artus's blacking, 123
Ashbery metal, 65
Atropine, 31
—— Gerrard's process for preparing, 33
Axle grease stains, cleaning, 323

B

BABBITT's anti-attrition metal, 52, 53
Baking powders, 87
—— —— ammonium bicarbonate, 87
—— —— Borwick's, 90
—— —— cream of tartar, 89, 90
—— —— Goodall's, 90
—— —— Horsford's, 90
—— —— phosphates, 89
—— —— Royal, 90
—— —— Rumford's, 90
—— —— sodium bi-carbonate, 88
—— —— sulphates, 89
—— —— tartaric acid, 88
Ball valves, noisy, 91
Bamboo, bending, 92
—— joining, 92
—— work, 92
Barley sugar, 394, 395
—— —— drops, 395
—— —— tablets, 396
Barometers, 94
—— aneroid, 105
—— Bogen's method, 95
—— cheap, 94
—— cistern, 99
—— cleaning tubes, 97
—— expelling air bubbles, 101
—— filling tubes, 96
—— fitting, 98
—— glycerine, 101
—— graduation of, 103, 104
—— mercurial, 103
—— portable mercurial, 103
—— reading, 103
—— siphon, 97
Baroscope, 104
Barrels, cleaning, 296
—— for alcohol, 24
Basket making, bleaching, 111
—— —— borders, 111
—— —— bottoms, 109
—— —— cane, 107
—— —— materials for, 107
—— —— osiers, 105
—— —— peeling osiers, 106
—— —— sides, 110
—— —— strokes, 108
—— —— tools, 108
—— —— varnish, 111
Bearing brasses, 53
Beeswax for candles, 202
Bell founding, 112
—— —— alloys, 112
—— —— metal, 54, 112
Belladonna, preparing alkaloid from, 31
Bells, casting, 114
—— moulding, 113
—— proportion of, 112
—— shape of, 113
—— table, 112
—— tuning, 114
—— weight of, 113
Belting, 115
—— cleaning, 116
—— lacing, 116
—— lubricating, 116

Benicke's cement, 227
Berberine, 33
Billiard balls, celluloid, 22[illegible]
Biram anemometer, 82
Bird clocks, repairing, 359
Birds' skins, cleaning, 301
Birmingham platinum, 76
Bismuth bronze, 54
Bitters, 117
—— Amazon, 117
—— Angostura, 117
—— Boker's, 117
—— brandy, 117
—— essence, 117
—— French cognac, 117
—— Hamburg, 118
—— nonpareil, 118
—— orange, 118
—— Peruvian, 118
—— Spanish, 118
—— stomach, 118
—— Stoughton, 118
—— wild cherry, 118
—— wine, 118
—— wormwood, 118
Blackboard wash, 119
Black flux, 41
Blackings, 120
—— Artus's, 123
—— Brunner's, 121
—— dress boots, 125
—— dubbin, 126
—— glacé kid boots, 125
—— guttapercha, 121
—— harness, 126
—— indiarubber, 123
—— Liebig's, 124
—— liquid, 120
—— Nicolet's, 121
—— paste, 123
—— saddlery, 127
—— tan boots, 125
—— waterproof, 124
—— wax, 125
Bleacher's ink, 130
Bleaching, 129-145
—— albumen, 129
—— anatomical specimens, 130
—— animal fibres, 159
—— baskets, 111
—— bleacher's ink, 130
—— bones, 130
—— coral, 130
—— cotton, 130
—— esparto, 130
—— fats and grease, 130
—— feathers, 130
—— gutta-percha, 132
—— hair, 132
—— horsehair, 132
—— ivory, 133
—— jute, 134
—— lace, 135
—— leather, 135
—— linen, 135
—— oils, 135
—— palm oil, 136
—— paper, 136
—— paper pulp, 137
Bleaching, paraffin, 137
—— prints and printed books, 137
—— pulp cane, 137
—— rags, 137
—— seaweed, 138
—— shellac, 138
—— silk, 139
—— silk yarn, 141
—— silver dials, 142
—— skulls, 130
—— sponge, 142
—— starch, 143
—— straw, 143
—— Tussore silk, 140
—— wax, 144
—— wicker-work, 144
—— wool, 144
—— woven silk, 142
Block fuel, 193
Blood albumen, 9
Blue gold, 65
—— prints, 416
Blunt leaved ornard, 106
Bogen's method of making barometers, 95
Boiler composition, 146
—— —— alkalies, 147
—— —— chemical, 149
—— —— Delfoisse's patent, 151
—— —— glycerine, 151
—— —— liquid, 148
—— —— oils and fatty matters, 148
—— —— physical processes, 140
—— —— powder, 148
—— —— tannins, 148
—— —— vegetable, 148
—— corrosion, 145
—— covering composition, 152
—— incrustation, 146
Boiling tallow, 209
Boker's bitters, 117
Bones, bleaching, 130
—— cleansing, 307
Bookbinder's paste, 267
Bookbinding, 153-193
—— backing, 161
—— blocking, 186
—— collating, 154
—— colouring calf, 187
—— colouring edges, 166
—— covering, 170
—— cutting, 164
—— drawing in, 163
—— finishing with dry preparation, 185
—— flexible work, 170
—— folding, 153
—— forwarding, 158
—— full gilt back, 182
—— gold work, 177
—— glueing up, 160
—— half-bound work, 172
—— hand finishing, 174-180
—— head bands, 168
—— inlaid work, 180
—— joints, 173
—— marking up, 156
—— millboards, 162
—— painted edges, 168
—— pasting on end papers, 159
—— pasting down, 172

Bookbinding, pasting up, 159
—— preparing for covering, 169
—— pressing, 163
—— repairing books, 190
—— rounding, 161
—— sawing in, 156
—— sewing, 157
—— sprinkling edges, 168
—— substitute for brass lettering, 190
—— trimming, 160
—— vellum, 185
Books, bleaching paper of, 137
Boot polish, brown, 125
—— —— glacé kid, 125
—— —— wax, 125
—— polishes, liquid, 120
—— top liquid, 123
Borders for drawings, 483
Borwick's baking powder, 90
Bottle cement, 230
Bottles, cleansing, 293
Brand's method of estimating alcohol, 28
Brandy balls, 396
—— bitters, 117
Brass, 55
—— cleansing, 294
—— colour, 55
—— colours of, 41
—— dipping and colouring, 446
—— for gilding, 57
—— for wire, 57
—— furnace, 47
—— fusibility of, 55
—— hard, 57
—— hardness, 55
—— inlaid work, cleansing, 294
—— instruments, cleaning, 294
—— lettering, substitute for, 190
—— malleability of, 56
—— melting, 56, 57
—— ordinary, 57
—— properties of, 55
—— red, 57
—— surfaces, ornamenting, 446
—— yellow, 57
Brasswork solders for, 74
Brightening iron articles, 307
Brimstone cement, 231
Briquettes, 193
—— coal dust, 193
—— sawdust, 194
Britannia metal, 57, 65
British gum, 247
Bronze, 58
—— blue, 75
—— cleaning, 295
—— Japanese, 65
—— manganese-tin, 66
—— red, 75
—— strength of, 72
—— tungsten, 75
—— yellow, 75
—— zinc, 77
Brown boot polish, 125
—— harness polish, 128
—— saddles, cleansing, 309
Brucine, 83
Brunner's blacking, 121
Brushmaker's cement, 231
Buckland's cement, 231
Buildings, dampness in, 436
Bullet metal, 58
Bullion lace, cleansing, 333
Burnishing, 195
—— cutlery, 197
—— pewter, 187
—— silver, 197
—— tools, 196
Burnt almonds, 397
Butter scotch, 394
Button brass, 57

C

CALF, colouring, 187
Calico, removing stains on, 320
Calumbine, 33
Cameo cutting, 198
Camera lucida, 198
—— —— for the microscope, 199
—— obscura, 201
Camphor, 219
—— distilling, 460
Canada balsam cement, 231
Candied chestnuts, 392
—— fruits, 392
—— sugar, 388
Candles, 202
—— composite, 211
—— diaphane, 211
—— dipping, 207
—— dips, 210
—— moulding, 208
—— pouring, 207
—— tallow, 209
—— transparent, 211
—— wicks, 205
—— —— pickling, 205
Cane, 107
Canned goods, solder for, 74
Cap cement, 232
Carbolic powder, 448
Carbon paper, 428
—— —— Dieterich's, 429
Cardamon comfits, 401
Carnauba wax, 203
Carpet, cleaning, 327
—— cleaning grease from, 321
—— vacuum cleaning, 295
Carraway comfits, 400
Carriage tops, restoring, 308
Cartier's hydrometer, 26
Cascarilline, 31
Casein cement, 233
Casks, cleaning, 296
Casting bells, 114
Catechu drops, 399
Catgut, 211
—— deodorants for, 213, 214
Caustic alcohol, 13
Celery comfits, 401
Celluloid, 215
—— billiard balls, 223
—— cement for, 224
—— cleaning, 297
—— colouring, 217, 223
—— dental, 222

Celluloid, hardening, 223
—— incombustible, 223
—— white, 222
Cellulose from potatoes, 223
Cements, 224
—— acid proof, 227
—— alabaster, 228
—— Algerian, 228
—— almond paste, 228
—— amber, 228
—— American, 228
—— aquarium, 228
—— architectural, 229
—— Armenian, 230
—— Benicke's, 227
—— bottle, 230
—— brimstone, 231
—— brushmaker's, 231
—— Buckland's, 231
—— Canada balsam, 231
—— cap, 232
—— casein, 233
—— celluloid, 234
—— chemical, 234
—— Chinese, 234
—— Chinese glue, 235
—— chrome, 235
—— colourless, 235
—— coppersmiths', 236
—— crucible, 236
—— curd, 236
—— cutlers', 236
—— dextrine, 236
—— diamond, 236
—— egg, 237
—— elastic, 237
—— electrical, 232
—— engineers, 237
—— Faraday's, 232
—— fat, 237
—— fireproof, 237, 239
—— flexible, 239
—— for acid chambers, 255
—— for cork, 236
—— for cover glasses, 262
—— for earthenware bisque, 236
—— for high temperatures, 233
—— for ivory, 253
—— for jet, 253
—— for labels, 253
—— for lamps, 255
—— for leather, 256
—— for mahogany, 257
—— for marble, 257
—— for meerschaum, 260
—— for metal letters, 257
—— for mother of pearl, 253
—— for parchment paper, 264
—— for porcelain letters, 257
—— for wood, 273
—— for zinc, 273
—— French, 239
—— Gad's, 259
—— glass, 239
—— glass to metals, 240
—— glycerine, 246
—— granite, 246
—— gum arabic, 246
—— guttapercha, 251
Cements, Hoenle's, 269
—— Hensler's, 248
—— hydraulic, 260
—— indianite, 250
—— indiarubber, 250
—— iron, 248
—— isinglass, 253
—— Japanese, 253
—— jewellers', 253
—— käseleim-pulver, 234
—— Keene's, 257
—— Keller's, 230
—— labels, 254
—— laboratory, 255
—— lead, 355
—— Lenher's, 237
—— London, 257
—— masons', 259
—— mastic, 260
—— metals to glass, 240, 261
—— microscopical, 261
—— milk, 263
—— mucilage, 264
—— naturalists', 264
—— opticians', 264
—— oyster shell, 268
—— Parian, 265
—— Paris, 265
—— plasters, 267
—— plumbers', 267
—— Pollock's, 246
—— porcelain, 267
—— rubber, 251
—— rubber to metal, 252
—— schio-liao, 234
—— shellac, 268
—— Singer's electrical, 233
—— soluble glass, 269
—— Sorel's, 269
—— Soulan's, 233
—— stone, 271
—— stonemasons', 271
—— to withstand petroleum, 267
—— turners', 271
—— tyre, 272
—— Ure's, 230
—— Varley's, 233
—— waterproof, 239, 272
—— Wollaston's, 273
—— zeiodelite, 273
Charcoal burning, 274
Chemical cement, 234
—— copying methods, 414
Chemists' hot air bath, 499
Chewing gum, 398
Cherries, cream, 391
Chestnuts, candied, 392
Chicory, alcohol, 20
Chimney cleaner, chemical, 27
Chimneys, smoky, 275
China, drilling, 289
—— riveting, 288
Chinese cement, 234
—— glue, 235
—— silver, 58
—— wax, 203
—— white copper, 76
Chisel steel, 291
Chocolate creams, 391, 393

Chocolate drops, 399
Chrome cement, 235
Chromium-iron alloy, 63
Chrysocale, 65
Cider casks, cleansing, 297
Cinchona bark, quinine from, 36
Cinnamon comfits, 401
—— drops, 399
Cistern barometer, 99
Circular melting furnace for alloys, 48
Clarifying tallow, 209
Cleaning alabaster, 293
—— alkali stains, 322
—— axle grease stains, 323
—— barometer tubes, 97
—— belting, 116
—— bores, 307
—— bottles, 293
—— brass, 294
—— brass inlaid work, 294
—— bronze, 295
—— carpets, 295, 321, 327
—— casks, 296
—— celluloid, 297
—— clocks, 348
—— clothing, 297
—— coffee stains, 322
—— coins, 298
—— copper, 294
—— cotton waste, 298
—— curtains, 329
—— dial plates, 316
—— druggists' utensils, 298
—— earthenware, 299
—— engravings, 299
—— feathers, 301
—— felt hats, 321
—— firearms, 302
—— floors, 321, 302
—— fire, 303
—— furniture, 321
—— gilt mountings, 303
—— gilt picture frame, 303
—— glass, 304
—— glass windows, 305
—— gloves, 306
—— gold, 306
—— hands, 307
—— harness, 307
—— hats, 307
—— Indian ink stains, 322
—— ink and iron mould, 321
—— iodine stains, 322
—— iron and steel, 307
—— ivory, 307
—— jewellery, 308
—— leather, 308
—— marble, 309
—— marking ink from fabrics, 322
—— microscope slides, 305
—— mildew from fabrics, 322
—— milk stains, 322
—— mirrors, 310
—— oil cloth, 310
—— paint, 310
—— paint brushes, 310
—— paint stains, 323
—— paintings, 310
—— parchment, 314
Cleaning pearls, 314
—— printers' ink from fabrics, 322
—— resin stains, 323
—— sheepskin mats, 314
—— silver, 315
—— stains from fabrics, 317
—— stearin stains, 323
—— stills, 323
—— sponges, 316
—— stone steps, 323
—— straw hats, 297
—— stuffed animals, 323
—— tapestry, 326
—— tannin stains, 323
—— tar stains, 323
—— tea pots, 324
—— textile fabrics, 324
—— varnish stains, 323
—— walnut stains, 323
—— washleather, 306
—— watches, 371
Clock bell metal, 112
—— mending, 337
Cloudy ammonia, 451
Clothing, cleaning, 297
Clove drops, 309
—— rock, 396
Coal economising powder, 381
—— dust briquettes, 193
Cock metal, 58
Coffee creams, 391
—— drops, 399
—— stain, cleaning, 322
Cognac, French, 117
Coins, cleaning, 298
Coke breeze concrete, 383
Colchicine, 34
Collating books, 154
Colour of copper-zinc alloys, 42
Coloured celluloid, 217
Colouring brass, 446
—— crayons, 434
—— celluloid, 223
—— drawings, 484
—— edges of books, 166
—— sweetmeats, 402
—— tracings, 485
Colours of alloys, 41
Colt'sfoot rock, 398
Comfits, 400
—— colouring, 401
Common jewellery alloy, 65
Compasses, using, 482
Composite candles, 211
Concrete, 381
—— walls, cracking of, 384
Confectionery, 387
—— cooked, 391
—— uncooked, 390
Cooking by steam, 404
—— range, causes of failure, 409
Copper amalgam, 80
—— cleaning, 294
—— solders for, 74
Copper-iron alloys, 61, 63
—— manganese alloys, 67
—— zinc alloys, colour of, 42
Coppersmiths' cement, 236
Copying, 414

Copying pencil, 427
—— —— Faber's, 428
—— —— Magne's, 423
—— drawings to a reduced scale, 488
—— paper, moist, 426
Coral bleaching, 130
Cordova wax, 128
Corks, cement for, 236
Corn starch paste, 265
Corrosion of boilers, 145
Cotton, bleaching, 130
—— waste, cleaning, 298
—— wicks, 205
Cover glasses, cement for, 262
Crayons, 434
Cream cherries, 391
—— of tartar, 89
—— of tartar baking powders, 90
—— for brown leather, 128
—— squares, 390
Crucible, cement for, 236
—— for melting alloys, 49
Crystallised fruits, 398
Cupola furnace, 48
Curd cement, 236
Curtains, cleaning, 329
Cutler's cement, 236
Cutlery, burnishing, 197
Cutting cameos, 198
Cymbals, metal for, 58

D

DAMASKS, cleaning, 329
Damp resisting glue, 245
Dampness in buildings, 436
Davidson's drying closets, 504
Delatot's white metal, 69
Delfosse's patent boiler composition, 151
Denatured alcohol, 23
Dendrometer, 441
Density of alloys, 42
Dental celluloid, 222
—— porcelain, 445
Dew ponds, 445
Dextrine cement, 236
Dial plates, cleaning, 316
Diamond cement, 230
Diaphane, 211
Dieterich's carbon paper, 429
Dipping brass, 446
—— candles, 207
—— metal, 65
Dips, 210
Disinfectants, 448
Distilling, 451
Distillation by dry heat, 513
Dividers, using, 482
Door hanging, 467
Doulton's drain-pipe, 469
Down draught in chimneys, 285
Drain-pipes, 469
Drawing, 479
—— board, 481
—— instruments, buying, 418
—— on glass, crayon for, 436
—— paper, sizes of, 479
—— pen, using, 481
Drawings, borders, 483
—— colouring, 484
—— copying, 420, 488
—— erasing errors in, 480
—— finishing, 482
—— framing, 487
—— indelible, 487
—— lettering, 482
—— mounting, 431
—— pencilling, 482
—— shading, 485
Dress-boots, blacking, 125
Dresses, cleaning, 333
Dressing for leather, 122
Drill for china, 289
Drilling chinaware, 290
—— glass, 290
Druggists' utensils, cleaning, 298
Drum timepieces, repairing, 357
Dry cleaning carpets, 327
—— distillation, 513
Drying and desiccating, 490–518
—— by cold, 518
—— fruit, 502
—— photographs, 508
—— pyroxyline, 219
—— rooms, 490
—— tea, 504
Dubbin, 126
Dumoulin's liquid glue, 244

E

EARTH wax, 203
Earthenware bisque, cement for, 236
—— cleansing, 299
Edge tools, bronze for, 58
Egg albumen, 11
—— cement, 237
Eggs as aerating agents, 7
Elastic cement, 237
—— glue, 246
—— leather dressing, 122
Electrical cement, 232
Electrotype plates, solder for, 74
Electrum, 66
Engineer's cement, 237
England's drying closet, 510
English clocks, 30-hour, 354
—— metal, 65
—— watch, repairing, 374
Engravings, cleansing, 299
—— mounting, 487
—— transfering to paper, 430
Erasing errors in drawings, 480
Escape wheels, repairing, 342
Essence bitters, 117
Esparto, bleaching, 130
Estimation of alcohol, 27
Everton toffee, 394

F

FAHLUN, 76
Faraday's cement, 232
Fat cement, 237
Fats, bleaching, 130

Feathers, bleaching, 130
—— cleansing, 201
—— scouring, 131
Felt-hats, cleaning grease from, 321
Ferro-concrete, 384
Feuille morte alloy, 65
Fibres, bleaching, 129
Fiddle strings, 213
Filing glass, 290
Filling barometer tubes, 96
Fine brass, 57
—— gold alloy, 55
Firearms, cleaning, 302
Fire lutes, 239
Fireproof cement, 237, 23
Fish albumen, 12
—— glue, 243
Fitting barometers, 98
Flannel, cleaning, 334
Flavouring sweetmeats, 402
Flax wicks, 205
Flexible cement, 239
Floors, cleansing, 302
—— cleansing grease from, 321
—— ferro-concrete, 385
Flowers, distilling, 461
Fluid disinfectants, 448
Fluxes for alloys, 44
Folding sheets for binding, 153
Footwalks, cement for, 259
Force and velocity of winds, 83
Formaldehyde, 449
Formalin, 449
French clocks, repairing, 361
—— putty, 268
—— rod osier, 106
Fresenius and Will's acidimeter, 6
—— —— alkalimeter, 29
Fruit alcohol, 14
—— drying, 502
—— stains, removing, 317
Fruits, candied, 392
—— crystallised, 398
Fumigating oil, 448
—— pastiles for, 450
Fur, cleansing, 303
Furnace, cupola, 48
—— for brass melting, 47
—— for melting alloys, 46
—— reverberatory, 49
Furniture, cleaning spots from, 321
Fusible alloys, 58
—— plug alloys, 59
Fusibility of alloys, 43
Fusible-malleable metal, 66
Fusing metals, 45
—— points of metals, 43

G

GAD's cement, 259
Gay-Lussac's hydrometer, 26
Gedge's metal, 50
Geisler's alcoholometer, 27
Geneva watch, repairing, 368
German clocks, repairing, 360
—— silver, 59
German silver manganese, 68
—— silver melting alloy for, 59
Germicide, 449
Gerrard's process for preparing atropine, 33
Gilding, brass for, 57
—— bronze for, 58
—— metal, 65
Gilt mountings, cleansing, 303
Ginger drops, 399
—— rock, 396
Glacé kid boots, blacking for, 125
Glass, cement for, 239
—— cleaning, 304
—— crayons for drawing on, 436
—— drilling, 290
—— filing, 290
—— to metals, cementing, 240
—— windows, cleansing, 305
Gloves, cleansing, 306
Glycerine barometer, 101
—— boiler composition, 151
—— cement, 246
Glue, 241
—— Chinese, 235
—— damp and moisture resisting, 245
—— elastic, 246
—— fish, 243
—— lip, 245
—— liquid, 244
—— marine, 258
—— portable, 245
—— quick drying, 243
—— to prevent cracking of, 243
Gold, alloys of, 65, 66
—— amalgam, 80
—— artificial, 60
—— blue, 65
—— burnishing, 97
—— cleansing, 306
—— solders for, 74
Gold-iron alloys, 62
Gong metal, 112, 115
Gongs, metal for, 58
Goodall's baking powder, 90
Graduation of barometers, 104
Grain alcohol, 17
—— drying, 506
Granite cement, 246
Grease, bleaching, 130
—— from floors, removing, 321
—— spots, cleaning from felt hats, 321
—— spots removing, 321
Grebe skins, cleaning, 302
Greenleaved osiers, 105
Grotto work, cement for, 259
Guards, inserting in books, 156
Gum arabic, 246
—— —— solutions, preserving, 247
—— artificial, 247
—— tragacanth, 247
Gun metal, 60
Gut, deodorants for, 213
—— scraping, 213
—— silkworm, 215
—— spinning, 212
Gutta-percha blacking, 121
—— —— bleaching, 132
—— —— cement, 251

H

HAIR, bleaching, 132
Hairsprings, fitting, 380
Hamburg bitters, 118
Hands, cleansing, 299, 307
Hard brass, 57
—— silver solder, 74
—— solders, 74
—— spelter solder, 74
Hardening celluloid, 223
Harness blacking, 126
—— brown polish, 128
—— cleansing, 307
—— oil for, 127
—— restoring soiled, 127
Hassell's drain pipes, 470
Hats, cleaning, 307
Hearthrugs, cleaning, 334
Heat insulators for boilers, 152
—— regulator, Anderson's, 511
Heating drying rooms, 492
Hectograph sheets, 422
Henault's anemometer, 84
Hensler's cement, 248
Hoenle's cement, 269
Hollow walls, 439
Homberg's alloy, 59
Horsford's baking powder, 90
Horsehair, bleaching, 133
Hot air bath, 499
House fronts, mastic for, 260
Hunt's microscopical cement, 261
Hydraulic cements, 260
—— press, alloy for, 74
Hydrometer, 25

I

IGNATIUS bean, preparing strychnine from, 39
Illustrations, copying, 426
Imitation pearl, 222
Impressions, alloy for, 61
Incombustible celluloid, 223
—— ivory substitutes, 223
Incrustation of boilers, 146
Indelible pencil drawings, 487
Indian ink, removing stains of, 322
Indianite cement, 250
Indiarubber blacking, 123
—— cement, 250
Ink, bleacher's, 130
—— stains, removing, 317, 318, 321
Inlaid binding, 180
—— work, cleaning brass, 294
Inoxidisable alloys, 60
Iodine, cleaning stains of, 322
Iron alloys, 61
—— —— properties of, 61
—— amalgam, 80
—— and steel, cleansing, 307
—— articles, brightening, 307
—— cement for, 248
Ironmould, removing, 321
Iridio-platinum, 61
Irish poplin, cleaning, 334
Isinglass cement, 253
Ivory, artificial, 223
—— bleaching, 133
—— cement for, 253
—— cleansing, 307
—— imitation, 222
—— substitutes, 215
—— —— incombustible, 223

J

JAPAN wax, 203
Japanese alloys, 64
—— bronzes, 65
—— cement, 253
Jet, cementing, 253
Jewellers' alloys, 65
—— cement, 253
—— solder for, 74
Jewellery, cleansing, 308
—— gold, 66
—— restoring the lustre of, 308
Jointing drain pipes, 469
Jones' hydrometer, 25
Jordan's glycerine barometer, 101
Journal box alloy, 66
Jute, bleaching, 134

K

KARAKENE, 112
Käseleim-pulver, 234
Keene's cement, 257
Keller's cement, 230
Kettle brass, 70
Kid gloves, cleaning, 306
Kisses, barley sugar, 396
Kitchen range, mastic for, 260
Komaromy's copying process, 425

L

LABELS, adhesive for, 253
—— mucilage for, 247
—— paste for, 254
Laboratory cements, 255
—— hot air baths, 308
Lace, bleaching, 135
—— cleansing, 335
Lacing belting, 116
Lama, cleansing, 334
Lamps, cement for, 255
Laundry drying rooms, 493
Lead cement, 255
Lead-iron alloy, 61
Leaks in aquarium, repairing, 87
Leather, bleaching, 135
—— brown cream for 128
—— cement for, 252, 256
—— cleaning, 308
—— covered mountings, restoring,
—— polishes, 120
—— polishes, Cordova wax, 128
—— preparing for bookbinding, 172
Lemarquand's alloy, 61
Lemon drops, 399

Lenber's elastic cement, 237
Letter, cement for, 257
Lettering drawings, 482
Lind's anemometer, 82
Liebig's blacking, 124
Linen, bleaching, 135
Lip glue, 245
Liquid boot polishes, 120
—— glue, 244
—— slating, 119
Locomotive bells, 112
London cement, 257
Lozenges, 397
Lubricating belting, 115
Lutes, 224
—— almond paste, 228
—— fire, 239
—— fireproof, 237
—— steam tight, 270

M

MAGNALIUM, 51
Magne's pencil, 423
Magnesia cements, 270
—— preparation for boilers, 151
Mahogany, cement for, 257
Malleable brass, 57
Malleability of brass, 56
Manganese alloys, 45, 66
—— German silver, 68
—— tin bronze, 67
Mannheim gold, 66
Manuscripts, restoring, 487
Maps, mounting for books, 155
Marble cement, 257
—— cleaning, 309
Marine glue, 258
Marking ink, removing, 322
Marlie's alloy, 61
Marzipan, 391
Masons' cement, 259
Mastic, 260
Materials for basket making, 107
Medals, alloys for, 69
—— bronze for, 58
Meerschaum, cement for, 260
Melting alloys, 44
—— Babbitt's metal, 53
—— furnace for alloys, 48
—— points of alloys, 41
Mercurial barometer, 103
Mercury, distilling, 462
Metal letters, cement for, 257
—— mirrors, alloys for, 50
—— to glass, cementing, 240, 261
—— to rubber, cementing, 252
Metals, fusing, 45
—— fusing points of, 43
—— mixing, 45
Methylated spirit, 23
Microscope, camera lucida for, 199
—— slides, cleaning, 305
Microscopical cement, 261
Mildew, removing from fabrics, 322
—— to remove, 310
Milk cement, 263
—— sour, as aerating agent, 8
Milk stains, cleaning, 322
Mirrors, cleaning, 310
—— metal, alloys for, 50
Mixing concrete, 383
—— metals, 45
Mock gold, 66
Molasses, alcohol, 15
Moreens, cleaning, 331
Morphine, 34
Mortars, bronze for, 58
Moss alcohol, 16
Mother of pearl, cement for, 253
Mounting drawings and tracings, 431
—— —— on linen, 479
—— engravings, 487
Moulding bells, 113
—— candles, 208
Mucilage, 264
—— for labels, 247
Muntz's metal, 69
Musical clocks, repairing, 356
—— instruments, cleaning brass, 294

N

NARCOTINE, 35
Naturalists' cement, 264
Neapolitan squares, 390
Nickel-iron alloy, 61
Nicolet's blacking, 121
Nicotine, 35
Nitrated cotton, 216
Nitric acid, 86
Nonpareil bitters, 118
Non-poisonous disinfectant, 449
Nougat, 393
Nut cream squares, 391
Nux vomica, preparing strychnine from, 39

O

ODOUR test for drain pipes, 473
Odourless disinfectant, 449
Oil for harness, 127
Oil paintings, cleaning, 311
—— —— lining, 311
—— —— restoring, 312
—— —— stopping, 311
—— palm, 204
—— stains, removing, 319
Oilcloth cleaning, 310
Oiling clocks, 352
Oils, bleaching, 135
Opticians' cement, 264
Orange bitters, 118
—— flower drops, 400
—— straws, 393
Organs, pipe metal for, 72
Orgeat drops, 400
Ornaments, bronze for, 58
Ornard, blunt-leaved, 106
Or-molu, 69
Osiers, 105
—— peeling, 106
Outdoor clocks, repairing, 356
Over-proof spirit, 25
Oyster-shell cement, 268
Ozokerit, 203

P

AINT, cleaning, 310
— stains, cleaning, 323
— stains on glass, removing, 305
— stains, removing, 318
aint-brushes, softening, 310
ainted edges for books, 168
aintings, cleaning, 310
alm oil, 204
— —— bleaching, 136
aper, aluminium, 79
— bleaching, 136
— carbon, 428
— polygraphic, 424
— pulp, bleaching, 137
— removing stains from, 320
— to parchment, uniting, 487
— transparent, 427
aperhangers' paste, 266
apyrograph, 421
araffin, 203
— bleaching, 137
aragon drain pipe, 471
arallel rule, using, 482
archment, cleaning, 314
— paper, cementing, 264
— to paper, uniting, 487
— vegetable, 487
arian cement, 265
aris cement, 265
—— salts, 449
arisian bell metal, 112
arker's alloy, 66
aste, 265
—— blacking, 123
—— bookbinders', 267
—— corn starch, 285
—— for prints, 268
—— for soda water labels, 254
—— paperhangers', 266
—— photographers, 265
—— starch, 265
—— that will not sour, 266
—— trimmers', 266
—— wheat starch, 266
astels, 434
astiles for fumigating, 450
eak metal, 70
earl, artificial, 222
—— imitation, 222
earls, cleaning, 314
eat briquettes, 194
eeling osiers, 106
encilling drawings, 482
encils, copying, 427
—— cutting, 480
Peppermint drops, 400
—— losenges, 397
—— rock, 396
Peruvian bitters, 118
Petroleum, cement to withstand, 267
Pewter, 69
—— burnishing, 197
—— plate, 66
Pewterers, solder for, 74
Phosphate baking powders, 89
Phosphor alloys, 71
Phosphor bronze, 72
Phosphorus, introducing into bronze, 71
Photograph, transfering to wood, 429
Photographers' paste, 265
Photographic drying box, 508
—— plate, cleansing, 304
Pickling candle wicks, 205
Picture frames, cleaning, 303
Pinchbeck, 72
Pipe chimneys, 279
—— covering composition, 152
—— metal for organs, 72
Piperine, 36
Piqués, cleaning, 334
Plants, distilling, 461
Plaster casts, repairing, 267
Plasters, 267
Plastic castings, amalgam for coating, 80
Plate pewter, 66, 69
Plumbers' cement, 267
Polishes, boot, 120
Pollock's cement, 246
Polygraphic paper, 424
Poppy, preparing morphine from, 34
Porcelain cements, 267
—— dental, 445
—— letters, cement for, 257
Portable glue, 245
—— mercurial barometer, 103
Portevin's powder, 424
Potato alcohol, 17
Potatoes as cellulose, 223
Pouring candles, 207
Preserving albumen, 12
—— gum arabic solutions, 247
Printed paper, bleaching, 136
Printers' ink, cleaning fabrics from, 322
Prints, bleaching, 137
—— pastes for, 268
Proof spirit, 25
Properties of alloys, 41
—— of brass, 55
—— of iron alloys, 61
Proportions of bells, 112
Pulp cane, bleaching, 137
Putty, 268
Pyroxyline, drying, 219
—— preparation of, 216
—— solvent for, 218

Q

QUEEN'S metal, 66, 72
Quinine, 36

R

RACK and gathering pallets, repairing, 345
Rags, bleaching, 137
Rahat lakum, 394
Railway signal bells, alloy for, 112
Raspberry drops, 400
—— rock, 396
Reading barometer, 103
Rectification of alcohol, 20
Red almonds, 398
—— brass, 57

Red gold, 66
Reinforced concrete, 384
Repairing albums, 192
—— books, 190
—— plaster casts, 267
—— stonework, 274
Resin, solvent for, 263
Resinous stains, removing, 317
Restoring insoluble albumen, 12
—— leather covered mountings, 127
—— manuscripts, 487
—— oil paintings, 312
—— soiled harness, 127
Reverberatory furnace, 49
Ring gold, 66
Rivet metal, 72
Riveting chinaware, 288
—— stake for clockwork, 343
Rooms, disinfecting, 448
Root alcohol, 16
Rose drops, 400
—— lozenges, 397
Rose's alloy, 59
Royal baking powder, 90
Rubber cement, 251
—— to metal, cementing, 252
Rumford's baking powders, 90
Rush wicks, 205

S

SADDLERY, blacking, 127
Saddles, cleansing, 309
Salicine, 39
Salted almonds, 393
Sanitary fluid, 450
—— powders, 450
Satin, cleaning, 332
Sauvage's alloy, 66
Sawdust briquettes, 194
Schio-liao cement, 234
Scouring feathers, 131
—— silk, 140
—— woven silk, 142
Seaweed, bleaching, 138
Seeds, distilling, 461
Serbat's mastic, 260
Sewer gas, detecting, 451
Shading drawings, 485
Shape of bells, 113
Shawls and scarves, cleaning, 335
Sheep dip, 451
Sheepskin mats, cleansing, 314
—— rugs, cleansing, 335
Sheet brass, composition of, 56
Shellac, 268
—— bleaching, 138
Shells, cementing, 265
Ship bells, alloy for, 112
Silk, bleaching, 139
—— damasks, cleaning, 330
—— handkerchiefs, cleansing, 335
—— scouring, 140
—— yarn, bleaching, 141
—— yarn sulphuring, 141
Silkworm gut, 215
Silver, alloy resembling, 76
—— alloys, 73
Silver amalgam, 80
—— burnishing, 197
—— Chinese, 58
—— cleaning, 315
—— dials, bleaching, 142
—— German, 59
—— metal, 51
Singer's electrical cement, 233
Siphon barometer, 97
Skulls, bleaching, 130
Sleigh bells, alloy for, 112
Smoke test for drain-pipes, 473
Soda-water bottle labels, paste for, 254
Sodium amalgam, 80
—— bicarbonate baking-powder, 88
Soft alloys, 73
—— solders, 74
Solar distillation, 456
Solders, 73
—— for brasswork, 74
—— for carved goods, 74
—— for copper, 74
—— for electrotype plates, 74
—— for gold, 74
—— for jewellers, 74
—— for pewterers, 74
—— for sealing iron in stone, 74
—— for tinned iron, 74
—— hard, 74
—— hard silver, 74
—— hard spelter, 74
—— soft, 74
Soluble glass, 269
Solvent for pyroxyline, 218
—— for rosin, 263
Sorel's cement, 269
Soulan's cement, 233
Sour milk, as aerating agent, 78
Spaniard osier, 105
Spanish bitters, 118
Specific gravity of alcohol, 25
—— heats of alloys, 44
Specular alloys, 74
Spelter soldering hard, 74
Spermaceti for candles, 203
Spinning sugar, 402
Spirit, proof, 25
—— distillery, 464
—— overproof, 25
—— underproof, 25
Sponge, bleaching, 142
—— cleaning, 316
Spoons, Britannia metal, 57
Spouts, Britannia metal, 58
Spring clocks, repairing, 355
Sprinkling edges of books, 167
Stains, removing, 317
—— on paper, removing, 320
Standard solutions of acid, 7
—— —— of alkali, 7
Starch bleaching, 143
—— paste, 265
Statuary, bronze for, 58
—— metal, 74
Steam cooling apparatus, 464
—— tight lutes, 270
Stearin stains, removing, 323
Stencils, 425
—— cutting, [illegible]

Stereotype metal, 74
Sterro metal, 74
Stills, cleansing, 323
—— for tinctures, 458
Stomach bitters, 118
Stone, cements for, 271
—— solder for sealing iron in, 74
—— steps, cleaning, 323
—— uniting broken, 270
Stonemasons' cement, 271
Stonework, repairing, 274
Stoughton bitters, 118
Stoves, fixing pipes for, 278
Stove work, mastic for, 260
Straight edge, testing, 481
Straw, bleaching, 143
—— bonnets, cleaning, 297
—— matting, cleaning, 336
Strength of alloys, 41
Strokes in basket making, 108
Strychnine, 39
Stuffed animals, cleaning, 323
Sugar, clarifying, 387
—— drops, 399
—— extracting acid from, 402
Sulphate and baking powders, 89
Sulphuring silk yarn, 141
Suspension spring, renewing, 316
Sweets, colouring and flavouring, 402
Sykes' drain pipe, 470
—— hydrometer, 25
Syrups, 88

T

TABARETS, cleaning, 331
Table bells, alloys for, 112
—— covers, cleaning, 335
Tailors' crayons, 436
Tallow boiling, 209
—— candle, 209
—— clarifying, 209
Tammy lining, cleaning, 332
Tam-tams, metal for, 58
Tan boots, blacking, 125
Tannin stains, cleaning, 323
Tapestry, cleaning, 326
Tar spots, removing, 234
—— stains, cleaning, 323
—— —— removing, 317
Tartaric acid, 88
Tea drying, 504
Teapots, cleaning, 324
Testing apparatus for drain pipes, 474
—— drain pipes, 471
—— straight edge, 481
Textile fabrics, cleaning, 324
Tilhet's copying process, 420
Tin amalgam, 80
—— brilliant, 76
—— iron alloy, 61, 64
—— manganese alloy, 68
—— scouring, 336
Tinned iron, solder for, 74
Tinting silk yarn, 141
Tobacco pipes, cleaning, 336
—— preparing nicotine from, 35
Toffee, Everton, 394
Tombac, 75
Tools for basket making, 108
—— for bookbinding, 174
Tracing cloth, 426
—— paper, 487
Tracings, colouring, 485
—— mounting, 431
Tragacanth, gum, 247
Transfer process on glass, 431
Transfering engravings to paper, 431
—— photograph to wood, 429
Transfers, 429
Transparent candles, 211
—— paper, 427
Trimmers' paste, 266
Tubania metal, 66
Tungsten bronzes, 75
—— steel, 61
Tuning bells, 114
Turkish delight, 394
Turners' cement, 271
Tussore silk, bleaching, 140
Type metal, 75
Tyre cements, 272

U

UNDERPROOF, 25
Ure's cement, 230

V

VACUUM cleaning, 295
Vanilla drops, 400
Varley's cement, 233
Varnish for baskets, 111
—— for leather, 124
—— stains, cleaning, 323
—— cleansing, 336
Vegetable albumen, 12
—— parchment, 487
Vegetables, drying, 502
Vellum, cleansing, 336
—— for bookbinding, 185
Velocity and force of winds, 83
Veretrine, 40
Verge watch, repairing, 365
Vermin, exterminating, 448
Vert d'eau alloy, 66
Victor metal, 77
Violet drops, 400
Violin bows, cleaning, 336
—— strings, 211
Violins, cleaning, 336
Vinegar, acidity of, 7[illegible]
—— casks, cleaning, 297

W

WALL papers, cleaning, 337
Walls, concrete, 386
Walnut stains, cleaning, 323
Washing compound for clothes,
Washleather, cleansing, 306
Watch mending, 337
Watches, repairing, 363

Water bath, constant, 517
—— heated air baths, 516
—— test for drain pipes, 472
Waterproof cement, 239, 272
—— blacking, 124
Wax bleaching, 144
—— boot polish, 125
—— Carnauba, 203
—— Chinese, 203
—— earth, 203
—— Japan, 203
Weights of bells, 113
Wheat starch paste, 266
White celluloid, 222
—— gold, 66
—— metal, 76
—— metal, Delatot's, 69
Wickerwork bleaching, 144
Wicks for candles, 205
—— cotton, 205
—— flax, 205
—— pickling, 205
—— proportions for candles, 206
—— rush, 205
Wild cherry bitters, 118
Willow bark, preparing salicine from, 39
Willis's copying process, 424
Winds, force and velocity of, 83
Wine stains, removing, 319
Wollaston's cements, 273
Wood, cementing, 273
—— on stone, mastic for bedding, 260
Wool, bleaching, 144
Woollen shawls, cleansing, 335
Wormwood bitters, 118
Woven silk, bleaching, 142
—— —— scouring, 142

Y

YELLOW brass, 57
—— dipping metal, 66
—— gold, 66

Z

ZEIODELITE cement, 273
Zinc amalgams, 81
—— bronzes, 77
—— cementing, 273
—— vessels, cleaning, 337

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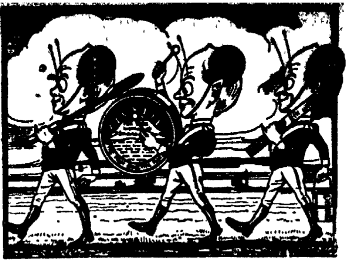

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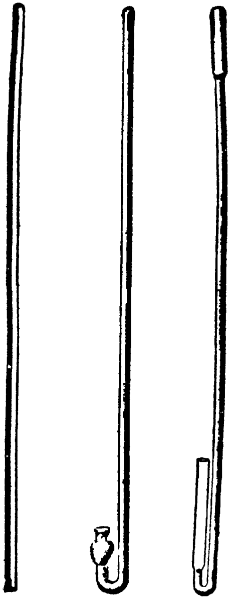

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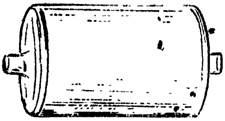

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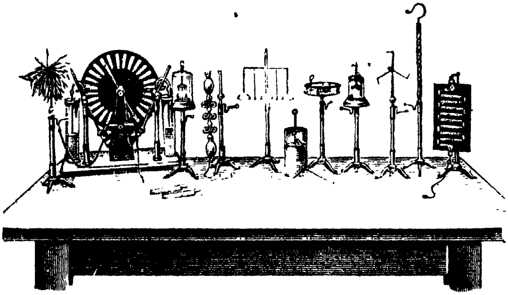

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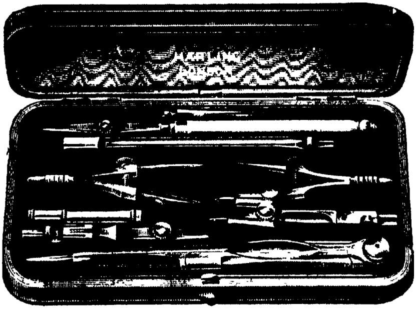

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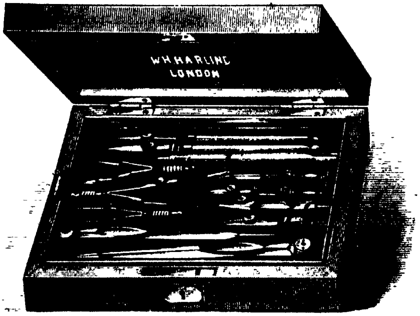

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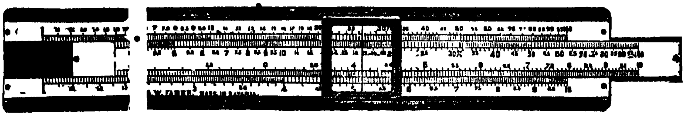
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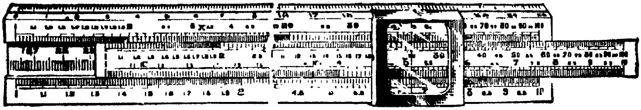

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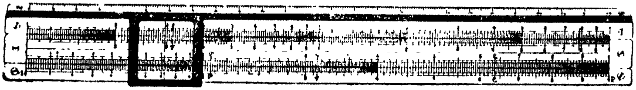

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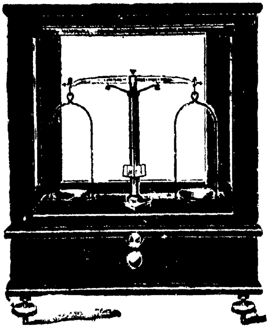

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	PAGE
AGRICULTURE	2
ARCHITECTURE	3
ARTILLERY	5
BRIDGES AND ROOFS	5
BUILDING	3
CEMENT AND CONCRETE	7
CIVIL ENGINEERING	8
DICTIONARIES	11
DOMESTIC ECONOMY	12
DRAWING	13
ELECTRICAL ENGINEERING	14
FOREIGN EXCHANGE	19
GAS AND OIL ENGINES	20
GAS LIGHTING	20
HISTORICAL; BIOGRAPHICAL	21
HOROLOGY	22
HYDRAULICS	22
INDUSTRIAL CHEMISTRY	24
IRRIGATION	27
LOGARITHM TABLES	28
MANUFACTURES	24
MARINE ENGINEERING	28
MATERIALS	30
MATHEMATICS	31
MECHANICAL ENGINEERING	33
METALLURGY	36
METRIC TABLES	38
MINERALOGY AND MINING	38
MUNICIPAL ENGINEERING	45
NAVAL ARCHITECTURE	28
ORGANISATION	40
PHYSICS	41
PRICE BOOKS	42
RAILWAY ENGINEERING	43
SANITATION	45
STRUCTURAL DESIGN	5
TELEGRAPH CODES	47
WARMING; VENTILATION	47
WATER SUPPLY	48
WORKSHOP PRACTICE	49
USEFUL TABLES	52
MISCELLANEOUS	53

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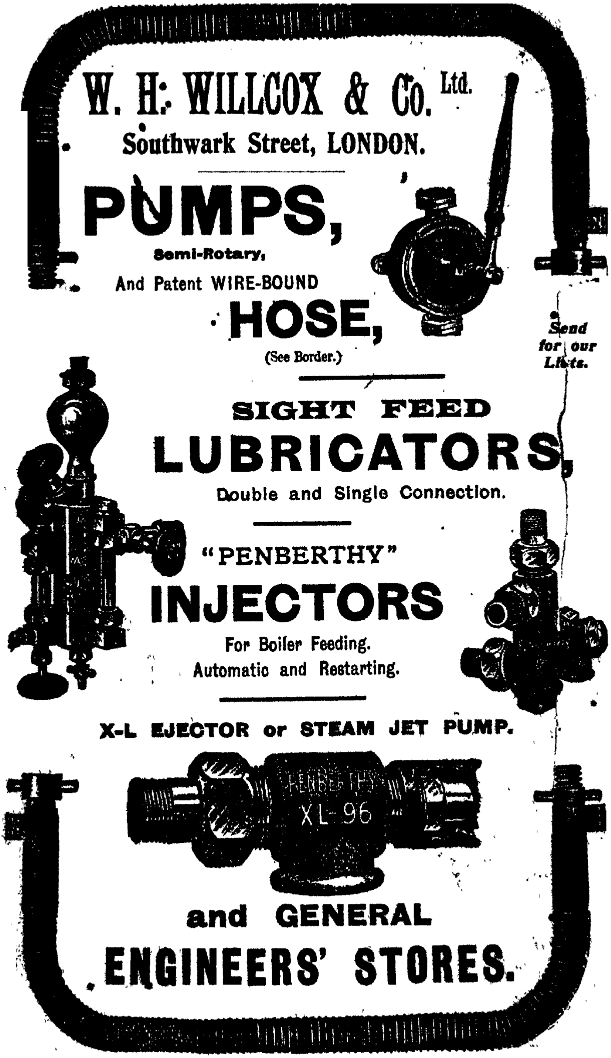

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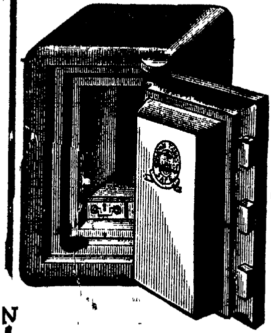

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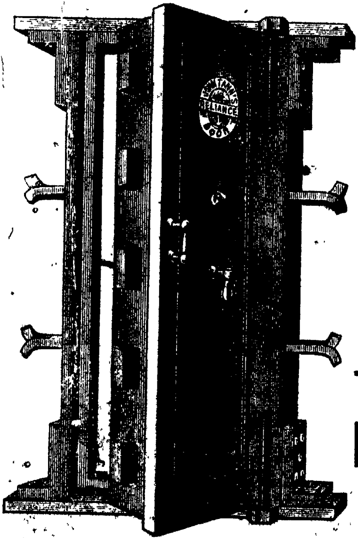

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